BLOCK 1 INTRODUCTION TO FOOD SCIENCE AND TECHNOLOGY

The science of food is the study of food components, their behavior under different environmental conditions, process of harvesting, milling, exposure to heat, cold, acid, alkalis etc. It covers all aspects of food raw material production, handling, processing, distribution, marketing and final consumption. For each food the processing methods evolved are based on their composition in terms of carbohydrates, proteins, fat, vitamin and minerals. Now food is a global commodity. Today, the field of food science has progressed from basic physical, chemical and biological reactions that take place during processing to the fields of biotechnology, food engineering, packaging and its effect on the consumer. New processing technologies now aim at not only increasing the shelf life but also retaining maximum organoleptic properties and qualities of fresh foods. The basic knowledge of food, its composition, need, effects of processing etc is essential in order to meet the demands of the market.

Unit 1 deals with **'Introduction to food science'**. After defining the food, its properties, constituents and chemistry are explained. Need of nutrition, digestive process, food spoilage and its effects are also discussed. This unit also covers the recent trends and new processes and equipments coming up in food processing. Food evaluation is discussed in brief.

Unit 2 is about **'Food processing industries'**. This unit explains about the world scenario of food processing, segments of food industries, status of food processing in India. It also covers problems and prospects of Indian food industries. The statuses of major food processing industries like cereal, pulse, horticultural crop, meat and fish industries are discussed. It also gives an overview of National Food Policy.

Unit 3 covers **'Food laws and associated bodies'**. Need pf food laws and standards are discussed. Indian and international food standards and regulatory bodies like PFA, FPO, MPO, BIS, AGMARK, AOAC, USDA, FDA, ISO, Codex Alimentarius are described. Quality assurance systems like HACCP, GMP and TQM are also discussed. This unit also gives an overview of export authorities of India, APEDA, MPEDA, NABL, and MFPI and their role. Product certification and licensing is also discussed in brief.

BPVI-001 FOOD FUNDAMENTALS

Block 1 Introduction to Food Science and Technology

Unit 1 Introduction to Food Science
Unit 2 Food Processing Industries
Unit 3 Food Laws and Associated Bodies

Block 2 Characteristics of Edible Agricultural Products

Unit 4 Food Grains, Pulses and Oil Seeds
Unit 5 Fruits and Vegetables
Unit 6 Dairy, Poultry, Meat, Fisheries and Marine Products
Unit 7 Commercial Crops, Spices, Medicinal and Aromatic Plants

Block 3 Nutrition

Unit 8 Nutritional Aspects
Unit 9 Food for Growth and Repair
Unit 10 Loss of Food Value in Fresh Produce and Processed Products
Unit 11 Anti-Nutritional Factors, Food Contaminants and Toxic Elements

Block 4 Quality Aspects

Unit 12 Quality Characteristics
Unit 13 Deteriorative Factors and their Control
Unit 14 Quality Assurance: Regulation, Codes, Grades and Standards

UNIT 1 INTRODUCTION TO FOOD SCIENCE

Structure

1.0 OBJECTIVES

After reading this unit, you should be able to:

- know constituents of food and properties;
- explain chemistry of food and nutrition;
- describe food spoilage and its effect; and
- discuss recent advances in food science and food evaluation.

1.1 INTRODUCTION – DEFINITION OF FOOD

Foods are materials, which in their naturally occurring, processed or cooked forms, are consumed by human beings for their nourishment, sustenance and enjoyment. Moreover food items are food grains (cereals: wheat, rice, coarse cereals like sorghum, millets etc.), legumes (pulses: red gram, black gram, green gram, beans), horticultural produce (fruits, vegetables, spices, condiments etc.), livestock produce (meat, egg, milk etc.) and fish (fish, prawns, crabs etc.). Beverages like tea, coffee, cocoa etc are also part of food.

Food sources in their natural form are cultivated, reared, captured or cultured. Some foods can be taken in raw form while most need some kind of processing to introduce desirable characteristics in them to make them acceptable, edible and digestible.

Food, as is known, is the essence of life. It is an exciting subject to study and know its importance and values. In earlier days human started experimenting on various forms and tastes. This led to the development of culinary art. Later on some people who developed special interest, became expert and earned name and fame. Much later it became a huge industry with a trade value of US$ two trillion.

Food Science and Food Technology can be defined as

Food Science: Food Science is the discipline in which the Biological and Physical Sciences and Engineering are used to study the nature of Foods, Causes of their deterioration and the principles underlying Food Processing.

Food Technology: It is the application of Food Science to the selection, preservation, processing, packaging, distribution and use of safe nutritious and wholesome food.

1.2 CONSTITUENTS OF FOOD, PROPERTIES AND THEIR SIGNIFICANCE

There are two important properties of food: nutritional value and taste (hedonic) value. The former is relatively easier to quantify since important nutrients are limited in number and their effects are more or less defined. Defining the taste is more difficult because it must take into account all those properties of food including visual appeal, smell, taste and texture, which interact with our senses. These properties are influenced by a large number of compounds, which in part have not been identified. Besides their nutritional and hedonic values, foods are increasingly being judged according to properties, which determine their handling.

1.2.1 Physical Properties of Foods

In broad sense, the physical properties of foods may be defined as those properties that lend themselves to description and quantification by physical rather than chemical means.

a) **Geometrical properties:** These encompass the properties of size, shape, volume, density and surface area as selected to homogeneous units. The geometrical characteristics of texture refer to structural geometry and structurally heterogeneous foodstuffs.

   Size and shape: The shapes of fruits and vegetables have been classified into 13 categories such as round, oblate, oblong, conic, elliptical, truncated, ribbed etc. the much prevailing method for quantitative shape description involves sphericity which is

   Sphericity = de/dc

   Where, **de** is the diameter of a shape of same as the test object and **dc** is its diameter of smallest circumscribing sphere (usually the longest diameter of the test object).

Size is usually characterized by determining the opening, as in sieve or screen, through which the product will or will not pass and measurement of diameter or length of product.

Volume, density and surface area: Volume and density measurement of liquid foods present no special problem, other than the proper control of temperature at which measurements are made. Standard volumetric methods (graduated cylinder) for volume quantification and pycnometer or commercial density meters for density measurement are simple. Volume of agricultural products, especially those exhibiting an irregular shape, is usually determined by water displacement. Density of solids can be determined by floatation in liquids (usually salt solutions) of different densities. Density of certain agricultural produce (peas, lima beans, potatoes) is an indirect measure of their texture also. Separation by density in floatation is also used with many agricultural commodities to remove defective materials and extraneous matter. Density is measured and defined in various ways like true density, substance density, particle density, apparent density and bulk density.

Surface area values have a meaning in heat transfer. A number of methods have been developed for calculating the surface area of products such as fruits etc based on shape factor measurement (e.g. areas of axial or longitudinal cross sections).

b) Optical properties: The most important optical properties from the quality point are colour and surface appearance (gloss) of the produce. These works on reflected light along with some spectrophotometer measuring light in both reflectance and transmittance modes. Transmitted light may be used for detecting defects such as water cores in apple.

Colour: It is one of the most important attributes and can separate a high quality produce (such as the golden yellow of a table orange) or can alert the consumer to a potential psychological danger (such as green processed meat). It also inferences flavour requirements in produce such as beverages and dessert gels and it affects consumer perceptions. Spectrophotometric method for colour description is based on three demarcations reflectance (lightness), dominant wavelength and purity. In this Hunter colour lab equipment colour scales L, a and b are used. L defines the lightness, a, the red-green lines and b the blue-yellow lines.

Gloss: The appearance of a surface, whether it is glossy or dull, is an important physical aspect of food quality detected by human vision. Typical of products where a shiny surface is valued as apples, cucumbers, cherries, on the other hand, oranges, green beans etc have dull surface. Gloss in the psychological attribute of surfaces associated with the spectrum reflects and can vary from surface to surface.

1.2.2 Rheological Properties

The complex nature of foods their variability and their diverse behaviour are some of the reasons for cataloguing separately the flow behaviour of specific foods.

The evaluation of rheological properties of solid foods can be divided into two broad classes. *Fundamental* tests measure properties that are inherent to the material and independent on the geometry of sample, the condition of loading or the apparatus e.g. modulus of elasticity, Poisson ratio, relaxation time, and shear modulus. *Empirical or imitator* tests are used to determine properties such as puncture force and extrusion energy where the mass of the sample, geometry, speed of test etc also determine the parameter estimated. The fundamental tests as applied to solid foods may again be classified into two essentially different groups: those divided under conditions of static (quasi-static) loading and those considered under dynamic conditions. Because foods are visco-elastic both time dependants and time independent measurements are required.

Foods that flow under gravity and do not retain their shape are considered to be fluid foods. Foods may exist as solids at one temperature and as liquid at other temperature (like ice-creams), suspension of solid matter is fluid media or emulsions. Because of wide varieties of their structure and composition, foods exhibit flow behaviour ranging from simple Newtonian to time dependent non-Newtonian and visco-elastic. For example, raw whole egg at 21 C was found to be a Newtonian fluid. However frozen egg was found to be a shear-thinning fluid.

1.2.3 Thermal Properties

Thermal properties are required to understand heat transfer during heating or cooling which foods are often subjected. Variability in composition and physical characteristics is typical for all food products.

The major thermal properties are specific heat, enthalpy, thermal conductivity, thermal diffusivity and heat transfer coefficient. These are much commonly used properties in designing a system for heating/ cooling of foods. These are several other properties that are thermal in value but are much less important to most heat transfer applications: melting/freezing point, latent heat, heat of respiration, heat of adsorption, coefficient of thermal expansion, dielectric constant, emissivity and absorptivity (radiation heat transfer).

1.2.4 Mass Transfer Properties

Mass transfer plays a very important role in basic unit operations of food processing. It is also involved in several physical, chemical and biological food processes such as salting, sugaring, oxygen absorption, de-aeration, and cleaning of process equipment. It is important in food processing and storage, where transfer of moisture; vapours/ gases and flavours components may influence food quality.

1.2.5 Electrical Properties

These properties determine the amount of energy coupled by a food product, its distribution within the product. Electrical properties are of most basic interest in high frequency food processing and their dielectric properties because these determine a number of related electrical properties, which affect energy coupling and its distribution within a food product. Biological material acts as heavy insulators i.e. non-ideal capacitors, in terms of their ability to store and dissipate electrical energy from an applied electromagnetic field by radiation transfer. These properties result form electric charging and less current generally related to materials electrical capacitance and resistance and are defined by fundamental dielectric properties.

1.3 FOOD CHEMISTRY: MOISTURE, CARBOHYDRATES, PROTEINS, LIPIDS, VITAMINS, MINERALS, AND PHYTO-CHEMICALS

Nutrients are naturally occurring chemical substances found in food. There are six categories of nutrients: proteins, lipids, carbohydrates, vitamins, minerals, and water. The chemistry of these nutrients influences the characteristics of our food. Proteins, fats, and carbohydrates in food provide the energy our bodies need to function.

1.3.1 Moisture

Every food material contains moisture. It is found in two forms i.e. free water and bound water. It is one of the most important attributes of the food material that affects processing, preservation and storage of foods. Fifty to 60 percent of human body weight consists of water. The fruits and vegetables contain 90% to 99%, fruit juices 80% to 89%, pasta, legumes, beef, and dairy 10% to 60%, and crackers and cereals contain 1% to 9% water.

1.3.2 Carbohydrates

The carbohydrates in diet come from plant foods. Simple carbohydrates include the different forms of sugar (monosaccharides and disaccharides); complex carbohydrates (polysaccharides) include starches and dietary fiber. Specifically they are composed of carbon and water and have a composition of $C_n (H_2O)_n$. No single carbohydrate is essential, but carbohydrates do participate in many required functions in the body. Carbohydrates may be divided into following categories.

Monosaccharides: It may have 6 carbons (called hexoses), or 5 carbons (called pentoses). Glucose (dextrose), fructose, and galactose are three common hexoses. Ribose and deoxyribose are two common pentoses.

Disaccharides: Two monosaccharides may be linked together to form a disaccharide. Sucrose (sugar) is the most common disaccharide and is made of one molecule each of glucose and fructose. Lactose is the major sugar in milk and is made up of one molecule of glucose and one of galactose. Maltose is a disaccharide made from two molecules of glucose.

Polysaccharides: Combination of more than two sugars is referred to as oligosaccharides, unless they are very large and then they are called polysaccharides. Raffinose and stachyose are two oligosaccharides. Nutritionally, polysaccharides are added to increase the dietary fiber content and functionally to thicken, form gel, bind water and stabilize proteins. Starch, cellulose, gums are main polysaccharides.

1.3.3 Proteins

Amino acids are building blocks of protein. Dietary protein is supplied from plant and animal sources. Proteins are polymers of amino acids. The shape and thus the function of a protein is determined by the sequence of its amino acids. Proteins must be broken down (hydrolyzed) to amino acids before they can be used. Once absorbed, amino acids are utilized to make proteins, converted to energy, or stored as fat. About 20 percent of the human body is made of protein.

Amino acids contain an amino group (-NH2) and an acid group (-COOH). There are twenty amino acids that are found in proteins. Amino acids join by forming peptide bonds. The conformation of a protein molecule in the native state is determined by the primary structure, the secondary structure, a tertiary structure.

Primary: The primary structure is the combination of amino acids in a proper sequence by means of the peptide bonds. No other forces or bonds are implied by this structural level designation.

Secondary: Secondary structure is that which forms a pleated or helix structure. The alpha helix is stabilized by hydrogen bonding between carboxyl and the amide groups of the peptide bonds that generally appear in a regular sequence along the chain of amino acids.

Tertiary: A tertiary structure is the folding of the coiled chain or chains. Covalent, hydrogen, and Vander Waals forces may be involved in the structural organization of protein molecules.

1.3.4 Lipids

Lipids include fats and oils from plants and animals. Lipids are the substances in foods that are soluble in organic solvents. This category includes fatty acids, triglycerides, phospholipids, pigments, vitamins, and cholesterol. Naturally occurring fatty acids have an even number of carbons. Reaction products of long-chain fatty acids are very important to the flavour of foods.

Fatty Acids: Fatty acids may be saturated or unsaturated (contain double bonds). A fatty acid that contains one double bond is called mono-unsaturated and with two or more double bonds is called polyunsaturated. Unsaturated fatty acids can exist in two forms, cis and trans, depending upon the arrangement of the portions of the fatty acid molecules around the double bonds. The double bonds in lipid molecules are highly reactive toward oxygen.

Triglycerides: Food fats are made up of three molecules of fatty acids connected to a molecule of glycerol and are known as triglycerides. The vast majority of foods contain fat in the form of triglycerides. Triglycerides are broken apart by lipases enzymes produces soapy flavour products. Triglycerides molecule that has had one fatty acid removed is called a diglyceride, two fatty acids removed is called a mono glyceride.

Phospholipids: Some fatty acids are connected to glycerol molecules that contain a molecule of phosphorus. These special lipids are known as phospholipids e.g. lecithin. They play important roles in the body but are not essential nutrients because the body can synthesize them in adequate quantities.

Cholesterol: Cholesterol is a compound produced by the body that has received considerable attention due to its reported link to heart disease. Some people have a genetic problem with the system that regulates cholesterol synthesis, and they produce excessive amounts. These people generally have greatly elevated serum cholesterol levels. This is of concern because high serum cholesterol is a risk factor for coronary heart disease.

1.3.5 Vitamins

Vitamins are chemical compounds in our food that are needed in very small amounts (in milligrams and micrograms) which regulate the chemical reactions in our body. The vitamins are divided into fat-soluble and water-soluble vitamins. Fat-soluble vitamins include vitamins A, D, E, and K. The water-soluble vitamins include the B vitamins and vitamin C. B vitamins include: thiamin, riboflavin, niacin, vitamin B_6, pantothenic acid, folic acid, biotin, and cobalamin (vitamin B_{12}).

1.3.6 Minerals

Minerals, which are also needed only in small amounts, have many different functions. Some minerals assist in the body's chemical reactions and others help form body structures. Minerals are important for energy transfer and as an integral part of vitamins, hormones, and amino acids. Depending on the amount in the body, minerals in the diet are classified as macro-minerals or micro-minerals (sometimes called trace minerals) as listed below:

Macro-minerals

Calcium	Chloride
Phosphorous	Magnesium
Potassium	Sulphur
Sodium	

Micro-minerals important in nutrition include:

Chromium	Molybdenum	Iodine
Cobalt	Silicon	Nickel
Copper	Tin	Selenium
Fluorine	Vanadium	Zinc
Manganese	Fluorine	

1.3.7 Phyto-chemicals

Phytochemicals exhibit diversified physiologic and pharmacologic effects. Active derivatives extracted from leaves, stems, roots, flowers, and fruits of plants may be classified into three main categories:

1. Toxic with no discernible therapeutic use; e.g. pyrrolizidine alkaloids, nicotine, and hydrazine derivatives

2. Toxic but useful for treatment of disease when used in controlled amounts; e.g. morphine, digitalis, and vinca alkaloids

3. Chemo preventative, useful against diseases; e.g. arteriosclerosis, cancer, and diverticular disease

Most active chemo preventative phytochemicals are high molecular-weight fibers such as celluloids, pectins, lignins, and low-molecular-weight compounds such as carotenoids, dithiolthiones, flavnoids, indole carbinols, isothiocyanates, mono- and triterpenoids, and thioallyl derivatives.

1.4 NUTRITION AND DIGESTION

1.4.1 Nutrient Needs

The requirement for a nutrient is that the minimum intake will maintain normal functions of the body and health. The main nutrients required by human beings are water, carbohydrates, protein, fat, vitamins and minerals. These are the source of energy. The nutrient needs of human beings are described below.

a) **Water:** Water is essential. About 65 percent of the adult body is made up of water. Lack of water can cause death more quickly than lack of any other nutrient. All the chemical reactions that occur in the body take place in water. Water also reacts during the chemical processes, regulates body temperature, transports nutrients and wastes, and dissolves nutrients. An adult should drink three to five litres of water each day.

b) **Carbohydrates:** Dietary carbohydrates include sugars, complex carbohydrates, starch and fiber. During digestion all carbohydrates except fiber break down into sugars. Sugars and starches occur naturally in many foods that also supply other nutrients. Examples of these foods include milk, fruits, some vegetables, breads, cereals, and grains.

c) **Fiber:** Fiber is found only in plant foods like whole-grain breads and cereals, beans and peas, fruits and vegetables. Eating a variety of fiber-containing plant foods is important for proper bowel function. Some of the health benefits associated with a high-fiber diet may come from other components present in these foods, not just from fiber itself. For this reason, fiber is best obtained from foods rather than supplements.

d) **Protein:** The nitrogen in protein is used for the synthesis of purines, pyrimidines, nucleic acids, adenosine triphosphate (ATP), hemoglobin, and cytochromes.

Depending on age and gender, humans require different levels of protein in their diet. Humans need the amino acids that the body cannot synthesize. These are known as essential amino acids. They include:

Phenylalanine	Methionine
Tryptophan	Valine
Histidine	Leucine
Isoleucine	Threonine
Lysine	Arginine

e) **Lipids:** In food, lipids are a source of essential fatty acids, gives that energy, act as carriers for flavours and fat-soluble vitamins, contributes to texture and mouth feel, is a pre-cursors of flavour, and provides heat transfer medium. The body can produce most of the fatty acids that it requires. It cannot make some fatty acids that contain double bonds. From linoleic acid (18 carbon fatty acid with two double bonds) humans can synthesize all the other fatty acids they require. Thus, linoleic acid is considered as an essential nutrient.

f) **Vitamins:** Table 1.1 lists the fat-and water-soluble vitamins and their functions.

Table 1.1: Functions of some vitamins

Vitamins	Some functions
Fat-Soluble vitamins	
Vitamin A	Growth and development of bone and epithelial cells, vision
Vitamin D	Absorption of dietary calcium and phosphorus
Vitamin E	Antioxidant in tissues
Vitamin K	Aids in blood clotting
Water-Soluble Vitamins	
Thiamin	Coenzyme in energy metabolism
Riboflavin	Coenzyme in many enzyme systems
Niacin	Coenzyme for cell respiration; release of energy from fat, carbohydrates and proteins
Vitamin C	Metabolism of amino acids, fats, lipids, folic acid, and cholesterol control, collagen formation
Vitamin B_{12}	Coenzyme for red blood cell maintenance and nerve tissue; carbohydrate, fat, and protein metabolism

g) Minerals: Table 1.2 lists some of the macro minerals and micro minerals and their functions.

Table 1.2: Functions of some minerals

Mineral	Some functions
Calcium	Bone mineral; blood clotting; nerve, muscle, and gland function
Phosphorus	Bone mineral, part of many proteins involved in metabolism
Iron	Part of haemoglobin and some enzymes, oxygen transport
Copper	Iron absorption, haemoglobin synthesis, skin pigments, collagen metabolism
Magnesium	Bone mineral, enzyme activator; energy metabolism
Sodium, Potassium, Chloride	Tissue fluid pressure and acid-base balance, passage of nutrients and water into cells, nerve and muscle function
Zinc	Activator of many enzymes
Iodine	Thyroid function
Manganese	Synthesis of bone and cartilage components, cholesterol metabolism
Selenium	Removal of peroxides from tissues, enzyme activation

1.4.2 Digestive Process

The processing of food takes place in four stages:

a) Ingestion: The act of eating. This is the first of the four main stages of food processing.

b) Digestion: Digestion breaks down food into molecules small enough to be absorbed. It breaks polymers into monomers that are easier to absorb and that can be used to synthesize new polymers required by the organism.

c) Absorption: Cells that line the digestive tract take up the nutrients. Nutrients are transported to the cells where they are incorporated into the cells and converted to energy that may be used immediately or stored until needed.

d) Elimination: In the last stage of food processing is elimination in which undigested wastes pass out of the digestive tract.

1.4.3 Components of the Human Digestive System

The following structures are considered parts of digestive system:

Mouth	Gall bladder
Tongue	Pancreas
Pharynx	Small intestine
Salivary glands	Large intestine
Esophagus	Rectum
Stomach	Anus
Liver	

1.4.4 Stability of Nutrients

The nutritive value of food starts with the genetics of the plants or animals. Fertilization, weather, maturity and harvest also influence the composition of the plant or animal being used for food. Storage before processing affects nutrient levels. Then all of the processing steps continue to affect the nutrient levels in a food. Finally, preparation in the home or at the restaurant can reduce the final nutritive value of a food before the digestive process.

Vitamin A is highly sensitive to acid, air, light and heat, vitamin C, D and thiamin to alkalinity, air, light and heat. Because of this sensitiveness, cooking losses of some essential nutrients may be in excess of 75%. A primary goal of food science is to preserve the nutrients through all phases of food harvesting, processing, storage, and preparation. Stability of nutrients under varying conditions of pH, air, light, heat, and cold is different. Nutrient losses are small in most modern food processing operations, but when nutrient losses are unavoidably high, the law allows enrichment.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are the major properties of food? Define them.

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2. Describe the chemistry of carbohydrates and proteins?

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3. What nutrients are required to our body and what are their functions?

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4. Describe digestive process of human.

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1.5 FOOD SPOILAGE AND ITS EFFECTS

All foods have a time limit of their usefulness that depends on the type of food, the storage conditions, and other factors. Shelf life is the time required for a food product to reach an unacceptable quality. It depends on the food item, the processing method, packaging, and storage conditions. Food spoilage includes changes in organoleptic quality, nutritional value, food safety, aesthetic appeal, colour, texture, and flavour. To some degree, all cause negative changes in the food as much as possible.

1.5.1 Types of Food Deterioration

The three general categories of food deterioration are physical, chemical and biological. Factors that cause food deterioration are many, including light, cold, heat, oxygen, moisture, dryness, other types of radiation, enzymes, microorganisms, time, industrial contaminants, and macro-organisms (insects, mice, etc).

1.5.2 Causes of Food Deterioration

Specific causes of food deterioration include number of factors as described below. These items can cause deterioration individually or in any combination.

Bacteria, Yeast, Mold: Thousands of species of microorganisms exist, and few hundred are associated with foods. Not all are bad because some are desirable in food preservation. Bacteria are single-celled organisms occurring in three shapes: round (cocci), rod (bacilli), and spiral (spirilla and vibrios). Some produce spores, and these spores are resistant to heat, chemicals, and other adverse conditions.

Yeasts are the largest of the microorganisms but are still single cells, and some produce spores. Molds are larger than bacteria. They are often filamentous, and they all produce spores.

In foods, microorganisms attack all the food components-sugars, starches, cellulose, fats, and proteins. Depending on the food and the microorganism, the action on food could be to produce acids, making the food sour, or produce alcohol. Some microorganisms produce gas, making the food foamy; still others produce unwanted pigments or toxins.

Environmental conditions that affect microbial growth include temperature and oxygen. Microbes that prefer cold temperatures are said to be pyschrophilic. Mesophilic microorganisms prefer normal temperatures; thermophilic microorganisms prefer hot temperatures. Bacteria or moulds that require atmospheric oxygen are said to be aerobic, and those yeast and bacteria that do not require atmospheric oxygen are called anaerobic. Facultative microorganisms are both aerobic and anaerobic; obligative microorganisms are either.

Insects: Insect damage can be minor, but the wounds facilitate additional damage by microorganisms. Insect damage and infestation can also be so much that it can make the food inedible.

Food Enzymes: All foods from living tissues have enzymes. At the time of harvest or slaughter, enzymes that control digestion and respiration proceed uncontrolled and cause tissue damage. Some of the post-harvest enzymatic reactions are desirable-for example, the ripening of tomatoes and the aging or tenderizing of beef. Heat, chemicals, and radiation can control enzyme action.

Heat and Cold: The higher the temperature, the faster the biochemical reactions. In fact, the rate of chemical reactions doubles with each 10-degree rise in temperature. On the other hand, subfreezing temperatures damage tissues. Cold temperatures may also cause discoloration, change the texture, break an emulsion, and denature protein. Chilling can injure the tissue of fruits.

Oxygen: Chemical oxidation reactions can destroy vitamins (especially A and C), alter food colours, cause off-flavours, and promote the growth of moulds.

1.5.3 Food-Borne Disease

Food infections are caused when a microorganism is present in the food and it causes infections in the human when the food is consumed. *Clostridium perfringen, Salmonella* sp., *Escherichia coli* and several others can cause infections. Food intoxication occurs when a food is consumed that contains chemical toxins which poison the humans. *Staphylococcus aureus* and *Clostridium botulinum* both produce toxins.

Microbes associated with disease: Disease-causing organisms that are associated with foods are very important from both a human health perspective and from economical perspective. The diseases that are caused by microbes associated with food are grouped into three categories: infections, intoxications, and toxico-infections.

Food-borne intoxications: Intoxications are the result of the ingestion of a toxin that is produced by a microbe living on the food product. The toxins that are produced by these organisms usually have a long half-life, even if the microorganism have died, the toxin remains. Intoxications also differ from infections in that the symptoms usually occur within hours after ingestion, instead of the days that are normally associated with food borne infections. Toxin producing strains of *Staphylococcus aureus* are responsible for staphylococcal food poisoning. It can be found in nasal passages, skin and throats of human. Most of these toxins are stable, even under heating conditions. The infective dose for the toxin is between 100-200 nanogrms.

Mycotoxins: Mycotoxins are toxins that are produced by molds that have the ability to grow on food products. Different species of *Aspergillus* and *Penicillium* can produce mycotoxins. Depending on the type of food and the conditions, the mold may be present or absent, even if the mycotoxins remains. Foods associated with mycotoxins include grains, such as corn, wheat, beans, rice and groundnut. If moisture is introduced, molds can grow and form mycotoxins. These toxins are then transferred into the food product that is made from the initial material.

1.6 RECENT TRENDS IN FOOD PROCESSING AND PRESERVATION

New food products and safe foods require new food processing methods and systems. In recent trends, firms exercising control over several stages of food production may increasingly dominate the food industry. This refers to the way products are acquired or traded in a market. Food industry firms form three basic types of vertical coordination.

Open production: A firm purchases a commodity from a producer at a market price determined at the time of purchase.

Contract production: A firm commits to purchase a commodity from a producer at a price formula establish in advance of the purchase. The contract farming comes in this group.

Vertical integration: A single firm controls the flow of a commodity across two or more stages of food production.

The food industry has traditionally operated in an open production system. However, more discriminating consumers, plus new technological developments that allow farm product differentiation, are contributing to a decrease in open production and vertical integration. Changing demographics and the increasing value of a person's time contributed to consumer preferences for a wide variety of safe, nutritious and convenient food products.

Providing food products with specific characteristics preferred by more discriminating consumers will likely involve increasingly more detailed raw commodity products, such as frying chicken of a specific weight and size, or a corn kernel with a specific protein content. This effort to carefully tailor raw commodities with processing in mind is already underway in food industries.

1.7 NEW PRODUCTS AND EQUIPMENT

The kind of food consumed is changing continuously and contributing to the competition and marketing. Over 10000 products are introduced each year in food processing sector. The initial focus of research was to reduce post-harvest losses through improved drying and storage technologies. Later research led to advances in processing techniques for food and feed. Latest research is being carried out to bring about improvement in safety and quality.

New industrial applications evolved, such as new forms of heat processing, low energy production, pasteurization, semi-finished production techniques (filtration, extraction, centrifugation), chilling and freezing. Now, computers are being used to develop sophisticated monitoring systems for instance scientists have developed computer sensors that continually measure plants 'vital signals' such as tissue temperature, and swelling and regulate the irrigation and atmospheric gas concentrations accordingly. Packaging technologies like vacuum packaging of milk have also improved.

Better grain storage techniques and post-harvest management allow developing countries with humid tropical climates to compete in the world grain markets with virtually insect free exports from temperate zones. Recent developments in biotechnology are fostering more concentrated seed production, vertical integration of production and processing and the need for segregated handling system to preserve the identity of distinct products.

New processes are continuously being tried in unit operations. New processes, which are coming up now, are Ohmic heating, irradiation, supercritical fluid extraction and high hydrostatic pressure technologies.

The success of freezing technology has opened a new field for food processors. Complete meals are being prepared now which are frozen until the consumer is ready to thaw and heat them. Many of these meals are sold in serving dishes. Other frozen foods, which are now coming up, are potpies, fish sticks, desserts and potatoes. Additives, food composition standards and labelling are also leading to the development of new products and machineries.

1.8 FOOD EVALUATION

Variety, season, geographical differences, harvesting, handling, processing, packaging, storage, display, home preparation, cooking, and serving influence nutrient content of foods. The food composition is determined by a variety of scientifically sound, standardized methods. The first system of approximating the value of food for nutritional purposes was developed at the Weende Experiment Station in Germany more than 100 years ago. This system separates a food into nutritive fractions. This system was known as proximate analysis. Various methods are developed to evaluate protein, carbohydrate, fat, vitamins and mineral, and fiber in the food. Some of the methods are standards developed by the Government organizations for quality analysis. Number of equipment and processes are also available for proximate analysis of food destructively or non-destructively. Newer methods of determining the composition of foods have replaced or supplemented the old proximate analysis and allowed determination of more specific nutrients in foods. These include spectrophotometry, liquid chromatography, and gas chromatography, which allow the determination of fatty acids, cholesterol, amino acids, specific minerals, and vitamins.

Food composition tables are used to evaluate the nutritional value of food supplies, to develop food distribution programs, to plan and evaluate food consumption surveys, to provide nutritional counselling, and to estimate the nutritional content of individual diets. The parameters that are evaluated for food evaluation are.

Description of food and measure
Moisture
Food energy (in Joules)
Protein, fat, different fatty acids (saturated, monounsaturated, polyunsaturated fatty acids and cholesterol), and carbohydrate (in grams)
Vitamins and Mineral (in milligrams and IU)

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are the main causes of food deterioration and what are their effects?

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2. What do you understand by food evaluation?

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1.9 LET US SUM UP

Food is essentially required for human being for energy. Nutrition is the processes by which the foods people eat provide the nutrients they need to grow and stay healthy. There are six categories of nutrients: proteins, carbohydrates, lipids, vitamins, minerals and water. The chemistry of these nutrients influences the characteristics of the food.

Food deterioration includes changes in organoleptic quality, nutritive value, food safety, aesthetic appeal, colour, texture and flavour. To some extent, all food undergoes deterioration after harvest. Deterioration may be physical, chemical or biological. Some deterioration produces toxins that are not destroyed by heat. Some of toxins produced by microorganisms can cause infections in humans.

The kind of foods people eat change in response to many influences such as demographic shifts, supply of ingredients, availability and costs of energy, politics, scientific advances in nutrition, health and food safety. New processing methods and approaches are coming up in food science.

The digestive process includes ingestion, digestion, absorption and elimination. Nutrients in the diet are progressively broken into smaller components by mechanical, chemical, and enzymatic means. Small molecules resulting from digestion are absorbed to supply the body with energy, protein, vitamins and minerals.

Food composition tables are used to evaluate the nutritional value of food supplies, to develop food distribution programs, to plan and evaluate food consumption surveys, to provide nutrition counselling and to estimate the nutritional content of individual diets.

1.10 KEY WORDS

Food	:	Foods are materials, which in their naturally occurring, processed or cooked forms, are consumed by human beings for their nourishment, sustenance and enjoyment.
Food infection	:	Illness produced by the presence and growth of pathogenic microorganisms.
Lipids	:	A broad group of fat like substances with similar properties.
Minerals	:	Minerals are needed only in small amounts and have many different functions in the human body.

Nutrition : It is the processes by which the foods people eat provide the nutrients they need to grow and stay healthy.

Nutrient needs : It is the minimum requirement for a nutrient intake that will maintain normal functions and health.

Protein : Large molecules of long chains of amino acids.

Properties of foods : Properties of foods include physical, rheological, electrical, thermal and optical properties of foods.

Triglycerides : Neutral fat molecule made up of three fatty acids joined to one glycerol molecule through a special chemical linkage called ester.

Vitamins : Vitamins are chemical compounds in our food that are needed in very small amounts to regulate the chemical reactions in our bodies.

1.11 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Your answer should include following points:

- Geometric, rheological, thermal, electrical and mass transfer properties;
- Significance of these properties.

2. Your answer should include following points:

- Chemical composition and bonding.
- Classifications.

3. Your answer should include following points:

- Nutrients needed.
- Significance, functions in body.

4. Your answer should include following points:

- Digestive process.
- Components of digestive system.

Check Your Progress Exercise 2

1. Your answer should include following points:

- Physical, chemical and biological causes
- Disease and other effects
- Mycotoxins and intoxications

2. Your answer should include following points:

- Proximate analysis
- Food evaluation table

1.12 SOME USEFUL BOOKS

1. Fellows, P.J. (1998) Food Processing Technology, Principles and Practices. Woodhead Publishing Limited. Cambridge, England.

2. Parker, R. (2003) Introduction to Food Science. Thomson Learning Inc. New York.

3. Potter, N.N. and Hotchkiss, J.H. (1995) Food Science, 5th Edition. Chapman & Hall Publishing Inc, New York.

4. Potter, N.N. (1987) Food Science. S.K. Jain for CBS Publishers & Distributors, New Delhi.

5. Potty, V.H. and Mulky, M.J. Food Processing. Oxford & IBH Publishing Co. Private Limited, New Delhi.

UNIT 2 FOOD PROCESSING INDUSTRIES

Structure

2.0 OBJECTIVES

After reading this unit, you should be able to:

- know scenario of food processing industries in India and world;
- explain trends of consumption of processed food;
- describe problems, prospects and status of food processing industries;
- learn about livestock and aquacultural processing industries; and
- explain national food processing policy.

2.1 INTRODUCTION

Food processing industries are major industries in developed countries. In developing countries, it is in growing stage. The food processing industires include cereals, pulses, oilseeds, bakery, horticultural crops, livestock and aquacultural produce etc. Now food is a global commodity and hence its processing industries will play important role in economy of any country. Type of food is now governed by consumers. The food processing in india is mainly done by unorganized sectors. So, there is a need to know the status of food procesing industries in india. The present unit covers the status of food processing industries in india, trends of food consumption, major processing industires of India and National Food Processing Policy.

2.2 FOOD PRODUCTION IN INDIA AND WORLD, PROCESSING AND VALUE ADDITION

The global food industry, with a value of US$ 2.2 trillion annually, is the single most important industry in the world economy. Food industry is expected to be worth $ 10 trillion by 2028 and most of this growth will come from developing world. The direct impact of the sub sector on growth and indirect stimulus to other type of economic activity carry important implications for employment, exports, food security and living standards. The development of food industries mainly depends upon the raw material coming from agriculture. The production of food grains of the world and percent share of India is given in Table 2.1.

Table 2.1: Production of major agricultural commodities and India' share in 2001

S.No.	Commodity	World production ('000 tons)	% Share of India
1.	Paddy	601128	21.9
2.	Maize	602814	1.9
3.	Wheat	585421	12.3
4.	Groundnut (in shell)	33802	17.7
5.	Sugarcane	1259906	23.3

On an average, agro-industries accounts for about 2% of GDP in developing countries but 9% in developed countries. The value of agro-processing is about three to four times that of agriculture in developed world, while it is typically a fraction of the value of agriculture in developing world. In developed countries, the share of total value added products in agro industries is 20-30%, whereas in developing world it is 30-45%.

The distribution of agro-processing industries within the developing world is relatively unequal. In 1997, 40% of agro-processing value added products in developing countries were concentrated in South and East Asia and Latin America. Among the developing countries, India ranked fourth with 9% value added products of the contribution from developing world. Trade in food products is increasing with a growth rate of 9.4% each year compared with an annual growth of 2.1% for agricultural commodities. Growth has been concentrated among developed countries. About 85% of European Union food exports are processed food while 60% of African export are primary commodities.

Now food is a global commodity. Food is traded and shipped around the world. The modern grocery store sells food from all over the world. These food might include cheese from Europe, beef from Australia, strawberries from Mexico, and apple from Argentina. The food processing industries are opening subsidiaries in other countries and fast food companies are opening outlets all over the world. Globalization and WTO will affect the world food processing industries to a great extent with the new global standards and food safety regulations.

2.3 PARTS OF THE FOOD INDUSTRY

The food industry is divided into four major segments:

i) Production
ii) Manufacturing/processing
iii) Distribution
iv) Marketing

Production: Production includes such activities as farming, ranching, orchard management, fishing and aquaculture. Technologies involved in production of the raw materials include the selection of plant and animal varieties, cultivation, growth, harvest, slaughter, and the storage and handling of the raw materials.

Manufacturing/processing: Manufacturing converts raw agricultural products to more refined or finished products. Manufacturing requires many unit operations and processes that are at the core of food sector.

Distribution: Distribution deals with those aspects conducive to product sales, including: product form, weight and bulk, transportation, storage requirements and storage stability.

Marketing: Marketing is the selling of foods in raw and processed form and involves wholesale, retail, institutions and restaurants

These four divisions are rather artificial as these actually overlap one another. Nevertheless, the food industry requires planning and synchronization in all its divisions to be successful. Another way of dividing the food industry is along major product lines:

- Cereals and bakery products
- Meats, fish and poultry
- Dairy products
- Fruits and vegetables
- Sugars and other sweets
- Fats and oils
- Non alcoholic beverages/alcoholic beverages

These divisions are typically where consumer consumption is measured and reported. Each segment can be divided into number of sub-segments. For example cereal processing may include wheat processing, pulse processing, bakery industries, weaning foods industries, fast food manufacturing etc.

Allied industries: Many companies do not sell food directly but they are deeply involved in the food industry. These are called allied industries. Allied industries produce non-food items that are necessary for marketing food. The packaging industry is a good example. Some specific examples include cans, food colour and flavour, paper products, and plastic products. Chemical manufacturers represent another group of allied industries. They supply the acidulants, preservatives, enzymes, stabilizers, and other chemicals used in foods. Monitoring and regulatory agencies such as the BIS, APEDA, FPO, Food & Drug Administration (FDA), lawyers, consumer action and information agencies, and other regulatory agencies are also part of allied industries.

2.4 TRENDS IN CONSUMPTION OF PROCESSED FOOD

Although expenditure on food has increased considerably over the years, the increase has not matched the gain in disposable income and hence percentage of income spent on food has declined. As income rises, the proportion spent for food declines.

Americans spent only about 8 percent of their personal consumption expenditures for food to be eaten at home. This compares with 10 percent for Canada and 11 percent for the United Kingdom. In less developed countries, such as India and the Philippines, at home food expenditures often account for more than 50 percent of a household's budget. In India, the percent total personal consumption expenditures spent on food consumed at home is 51.3%.

Consumption trends change over the years, and this influences what the food industry does. However, demand for individual foods is more responsive to prices as consumers substitute among alternative food commodities. Rising incomes increase expenditures on more expensive foods, as consumers demand more convenience and quality. Demographic factors, such as changes in household size and the age distribution of the population, can bring about changes in consumption.

Away-from-home meals and snacks now capture almost half (45 percent) of the U.S. food dollar. This is up from 34 percent in 1970. Fast food accounts for the largest and fastest rising share of sales in the food industry. Sales in fast-food industries now outpace the sales in full-service restaurants. People want quick and convenient meals. They do not want to spend to much time in preparing meals, travelling to pick up meals, or waiting for meals in a restaurant. Consumers want to combine mealtime with time engaged in other activities such as shopping, work, or travel. For example, McDonald's, Pizza hut, KFC, Burger King, Taco Bell, and others are now located in conversant outlets.

2.5 STATUS OF FOOD PROCESSING IN INDIA

India is the world's second largest producer of fruits & vegetables, but hardly 2% of the produce is processed. India is the land of spices producing all varieties worth over Rs. 3500 crores (US $ 900 million) amounting to 25-30% of world production, which is processed for value-addition and export. It grows 22 million tonnes of oilseeds covering most of the varieties. Other important plantation products include tea, coffee, cocoa and cashew.

India's livestock population is largest in the world with 50% of world's buffaloes and 20% of cattle, but only about 1% of total meat production is converted to value added products. India is the largest milk producer in the world but only about 15% of the total milk production is processed through the organized sector. Size of the semi-processed and ready to eat packaged food industry is over Rs. 4000 crores (US $ 1 billion) and is growing at over 20%.

India has become a surplus producer of food from being an importer of food grains. However, India does not figure significantly in the world trade of food and food products. Food processing industry in India has been stagnant for a long time, although consumers in India spend more than half their expendable income on food, beverages and tobacco totalling almost Rs. 4000 billion.

There are a large number of small and medium size processing units and only a few large process houses. There are more than 800 flour mills, almost 600 fish processing units with about 4500 cold storages, over 5000 fruit and vegetable processing units, 170 meat processing units, about 650 soft drink units, more than 400 sugar mills and 700 solvent extraction units. With bigger units run by multi national companies, the number may not change significantly but there might be a qualitative change in the character of the industry.

Processed food industry ranks 5th in size in India accounting for about 5.5% of GDP, employing more than 1.5 million workers in the industry with a size of about US$ 30 billion. More than 75% of the industry is in unorganized sector in terms of turnover with value added foods account for US$ 17 billion. The size of semi-processed and ready-to-eat/packaged food industry is about US$ 1 billion.

Processed foods worth over US$ 4 billion were exported in 2002-03, of which rice is about 46% and marine products about 34%. Major exports besides rice and fish products, have been fruits and vegetable products, meat and poultry products both fresh and frozen, egg products and tea. There are good prospects of having grains and grain products as well as milk and milk products also among the major export items.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. How the food industries are segmented?

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2. What is the status of food processing in India?

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2.6 MAJOR FOOD PROCESSING SECTORS THEIR STATUS, PROBLEMS AND PROSPECTS

Food processing industry in India can be segmented as follows:

1. Cereal/ pulse milling
2. Fruit & vegetable processing
3. Milk & milk products
4. Beverages like coffee, tea & cocoa
5. Fish, poultry, eggs & products
6. Meat & meat products
7. Aerated waters/soft drinks
8. Beer/alcoholic beverages
9. Bread, biscuits & other bakery products
10. Edible oil/fats.
11. Confectioneries
12. Breakfast cereals, malt protein, weaning, extruded food products

2.6.1 Problems in Food Processing Industries

At present most of the industries are in unorganized sectors. So, numbers of problems are arising from different sections of the industries. Some of the basic problems encountered by Indian food industries at different levels are given below.

Farm level problems

- Poor yield of farm produce and therefore low returns
- Lack of material resources necessary for development
- Primitive methods of farming
- No control on quality of inputs and lack of finance to manage.
- Vagaries of weather
- Unavailability of reliable handling and transportation system
- Lack of storage facilities at farm

Distributors problems

- Lack of modern transportation facilities and high cost
- Inadequate cold storage faculties
- Irregular quality of farm produce

Processing industries problem

- Financing
- Higher import duties
- Higher cost of raw material and packaging
- Inadequate transport and cold storage facilities
- Infrequent availability of refrigerated containers
- Staggering advertising costs
- Limited domestic market

Consumer discontent

- Does not get value for money
- The price variation is a day to day affair
- Continued dependence on seasonal products
- Lack of variety of semi processed or prepared convenience food at affordable prices.

The reasons for slow growth of processed foods in India in past are many. Majority of the population has low-income levels and cannot afford processed foods. Indians traditionally prefer fresh foods that are cooked rather than use preserved foods. There is also no national character for food habits and these keep changing from region to region. However, the scenario is changing with some foods especially the fast foods acquiring the national character. Also some foods such as idli, dosa, some Punjabi foods like chhole, alu mutter etc., some Chinese foods and now the western foods like burgers and pizza are fast gaining national popularity.

There are some factors that impede growth in this industry. Transport (both road and railways) and communication are poor. This causes special problems for perishable products. There are no reliable cold chains, which are necessary for temperature sensitive foods like fruits & vegetables, ice creams etc. Modernization is unaffordable for small-scale manufacturer but the large companies do not find investment justifiable due to small size of market. Packaging costs are high. Even the retail business in small stores so large that an inventory needed to display various brands and that is lacking. Supermarkets are not yet popular although a few are making appearance.

2.6.2 Prospects

Indian government is now making an effort to promote better growth of this industry by giving it a priority sector status for lending by banks, most of the industry (except in alcoholic beverages and those products reserved for small scale), have been exempted from licensing, have relaxation in small scale reservation, foreign technology agreements, agro-based export oriented units, assistance in research and development etc. Government is also trying to improve infrastructure support such as cold chain facilities, transport, storage warehouses, etc. Governments are setting up Food Parks, 10-year tax holiday, and replacement of PFA Act with a new more rational act. The bill for Integrated Food Law is likely to be introduced in the Parliament.

Because of liberalization and other developmental measures being taken, future of the industry looks very bright. To some extent cold chain is being provided, which will help in retaining quality, freshness and reduce post-harvest losses. With the new hybrid varieties being added the production season is also being extended. These developments shall result in the greater availability of quality raw materials to the industry thus resulting in better capacity utilization and producing a wider range of products and of international quality. The quality is now the watchword for success. The multinationals now entering the food industry have an international marketing network and have their brand loyalties all over the world. This will enable the Indian products reaching all over the world in the form and packing required.

With the rise in the per capita income particularly of the middle classes a drastic change in the food habits has been noticed. This will lead to an increased domestic consumption of processed foodstuffs.

2.7 CEREAL PROCESSING

India produces about 200 million tonnes of different food grains every year. All major grains like paddy, wheat, maize, barley, and millets like jowar (great millet), bajra (pearl millet) & ragi (finger millet) are produced in the country.

The country is self sufficient in grain production and is the second largest wheat and rice producer in world, with a 20% share in total world production.

Primary milling of rice, wheat and pulses is the most important activity in food grains. There are over 91,000 rice hullers and 2,60,000 small flourmills engaged in primary milling. Further there are about 43,000 modernized rice mills/huller-cum sheller and the quantity of rice bran processed for bran-oil extraction stood at 3.4 million tonnes in 1999-2000.

Around 820 large flourmills in the country convert about 10.5 million tonnes of wheat into wheat products. Branded rice is becoming popular in the country and significant corporate presence is there in the domestic as well as export markets. Some quantity of wheat and wheat products is also exported.

The total market of bakery product, bread and biscuit is 1.5 million tonne and 1.1 million tonne respectively in year 1998. The cake market alone is estimated at 0.4 million tonne. The organized segment of the biscuit market is estimated to be 0.44 million tonnes whereas the unorganized sector accounts for the balance 0.66 million tonnes. Bread market is estimated to be growing at around 7% per annum in volume terms, whereas the biscuit market in the recent years has witnessed a little higher growth at around 8-10% per year.

Besides the industrial areas in leading metropolis, the bakery products and confectionery are carried on small-scale basis also at household level. Whereas, the confectionery industry has developed remarkably with the international brands mingling with the domestic market toffees, chocolates etc. produced at large scale in important industrial regions of the country. During the last 2 decades, small and unorganized players shared the growth in the industry. Currently, there are an estimated 2 million bakeries across the country engaged in production of bread, biscuits and other products. The estimated annual production of bakery products in India is in excess of 3 million tonnes, of which bread accounts for nearly 50% and biscuits 37% in volume terms in the organized sector. Sugar-boiled confectionery, consisting of hard-boiled candy, toffees and other sugar-based candies, is the largest confectionary segments and valued at around Rs 2,000 crore. The confectionery industry has a current capacity of 85,000 tons; the market is growing at the rate of 10-15% per annum.

2.8 PULSE PROCESSING

In India, around 75% of pulses produced is consumed after having been milled for removal of the husk and splitting or after some processing. Losses take place at various stages after harvest viz. during storage, loosening of husk, at the time of processing, etc. Among post harvest operations, storage causes the maximum loss of 7.5%, processing, threshing and transport causes 1%, 0.5% losses respectively, aggregating 9.5% total loss. Though the main cause of low per capita availability is considered to be poor productivity and production but reduction in post harvest losses can enhance the availability to a considerable extent. However, most of the commercial technologies available for this purpose are either obsolete or inadequate and result in heavy losses due to breakage and powdering of the grain. Successful efforts have been made to develop improved technologies to reduce milling losses and improve product quality. Similarly there is a need for development and utilization of improved technologies for the manufacture of products based on grain legumes.

Conversion of pulses to dhal is the third largest food processing industry in the country after rice and wheat milling industries. It is estimated that about 75% of the pulses produced in the country are converted to dhal. Milling of pulses has been practiced as a small-scale rural operation from time immemorial and more recently as large commercial operation. About 30% of the production of pulses is retained by the farmers and is processed in rural sector using traditional techniques. Presently the dhal available in the market comes almost entirely from the large-scale mills. There are about 10,000 dhal mills working in various parts of the country processing different pulses throughout the year.

A majority of the 5500 mills, reported in the country are big and semi-automatic/ automatic. They process more than 80% of the pulses produced in the country. However, there is a good scope for new entrants in this field is of particular significance as pulses are the main suppliers of proteins and nutritious food to the poor masses.

Depending upon the scope for processing pulses, dhal-milling plants can be setup in rural areas so that the waste material available from this industry could be beneficially used for cattle feed and other purposes.

Many pulse milling machines, technology and process have been developed by different research organizations of the country to overcome most of the anomalies of the traditional methods. Some of these methods have better milling efficiency, more yield in lesser time and at lesser processing costs compared to the traditional process.

2.9 OILSEED PROCESSING

The vegetable oil processing and extraction industry also plays a vital role in our edible oil economy. It comprises the orthodox bullock driven crushers and the modern expander/extruder units. In recent times the processing sector has passed through a transitional phase, attempting to cope with the rapidly changing processing methods the world over.

Over the years the demand for both edible and inedible oils in India has been on the rise. The gap between demand and supply has been largely bridged by using innovative technologies and unconventional oil sources from forest based oilseeds. In recent years per capita consumption of edible oil has also been rising. It was estimated that edible oil demand would be about 7.1 million tonnes or 26 million tonnes of oilseeds. Although India produces about 7 million tones of edible oils annually, a gap may still arise as the industry sources are expecting an increase in our annual per capita consumption of edible oil to 9 kg. The domestic demand for edible oils has been growing at about 6.7 percent per annum whereas production only at 4.5 percent per annum.

The processing by the solvent extraction industry declined to 10.4 million tonnes in 1996 compared to 11.2 million tonnes in the previous year. Exports of oil meal, oilseeds and minor oils have reached 4.55 million tones) valued at Rs. 3766 crores ($ 1067 million) during the year 1996-97 at against 4.54 million tonnes (valued at Rs. 2873 crore equivalent to $ 820 million) in 1995-96, i.e. a quantum jump of 35 per cent over the previous year.

India has about 2.5 lakhs ghanis and kolhus and around 50.000 oil mills of different capacities. While most of the former categories have low productivity, majority of the oil mills have only the capacity of 1 to 5 tonnes per day and about 150 are having that of 50 tonnes per day.

Vanaspati production has been growing at an annual rate of 1.6 per cent during 1990-91 to 1995-96. Yet of its 161 units, 49 have put down the shutter during 1996. The vanaspati producer's are pressing for decontrolling the use of mustard oil in vanaspati production. Now the Vegetable Oils Products (VOP) industry is permitted to use only certain specified varieties of mustard. High input cost is a major constraint faced by the manufacturers. The vanaspati industry's capacity utilization went down to 36 per cent in 1994-95 from a high of 66 per cent in 1987-88. The industry has also added substantial capacities is complete disregard to the market demand, 26.6 lakh tones in 1994-95 compared to 15 lakh tones in 1986-87.

For increasing domestic production potential for vegetable oil (edible & industrial) from non-conventional sources, and integrated approach is necessary for exploitation of non-traditional oilseeds. Soybean and oil palm are two promising oil bearing materials for achieving self-sufficiency for India.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are the major problems and prospects of processing industries?

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2. What is the status of grain and oilseed milling in India?

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2.10 HORTICULTURAL CROP PROCESSING

The commercial processing of fruit & vegetables is less than 2%. The main reason being that domestic consumption of processed items is quite meagre because of economic reasons and also as a matter of habit as consumers prefer fresh fruits & vegetables. The high cost of packaging pushes up the cost of the processed items and thereby makes them out of reach of the common man. Because of the varied agro-climatic conditions some fresh fruit & vegetable are available throughout the year.

Presently there are a little over 5198 units registered under the FPO distributed all over the country. Most of the units fall in the cottage and or small-scale sector. A few modern processing plants have, now come up and many more are in the pipeline. The installed capacity, which was 11.08 lakh tonnes, in 1993, increased to 21.00 lakh tonnes at the end of the year 1999. After the liberalization of the economic policies in the country, a few very modern plants produce mango pulp, tomato paste etc. in aseptic packing, freeze drying of many fruit & vegetables including mushroom is being taken up. It is expected that in the years to come, many modern state of the art plants shall come up.

The important items manufactured in the country are fruit pulps particularly of tomatoes & mangoes, ready to serve juices, canned fruits, jam, pickles, squashes, etc. Recently, items like frozen fruits, pulps, dehydrated & freeze-dried vegetables, canned mushrooms etc. are also being produced. In the coming years, new industries like carbonated fruit drinks, dehydrated and freeze dried fruits, fruit juice concentrates are expected to come up.

India in a small way has been in the export market for almost 30 years. Among the popular items in export are mango chutneys, pickles. Fruit juices, canned and dehydrated mushrooms, frozen & canned fruit & vegetables. In the year 1997-98 the exports of processed fruit and vegetables were in the order of 299 thousand tonnes valued at Rs. 761 crores (US $ 200 million).

Due to the WTO Agreement, all the exporting units will have to follow the Codex Alimentarius standards. This makes the compliance easier as one does not have to try to comply with several different legal requirements of different countries. There are many processors who export their products to several countries. Codex Alimentarius also has another requirement and that is Hazard Analysis and Critical Control Points (HACCP). This has been incorporated to ensure safety of food products. Although this is new to most Indian manufacturers, several processing units have already incorporated these requirements in their units.

The future looks quite promising for food processing industry. It is bound to grow at much more healthy rate as many plans are implemented. Government has a big role to play in its development and has already given its willingness to help the industry.

2.11 LIVESTOCK AND AQUACULTURAL PRODUCE PROCESSING

2.11.1 Fish Processing

With over 8000 km. of coastline, 3 million hectares of reservoirs and 1.4 million hectares of brackish water, India has vast potential for fishes from both inland and marine resources. Units mostly exist in the small-scale sector as proprietary or partnership firms or fishermen co-operatives. Over the last decade, the organized corporate sector has become increasingly involved in preservation, processing and export of coastal fish. But the wide variety of fish resources found in Indian inland waters, coastal areas and deep seas comprising India's Exclusive Economic Zone, still remain grossly under utilized

Processing of produce into canned and frozen forms is carried out almost entirely for the export market. In all, there are about 393 freezing units, 13 canning units, 160 ice-making units, 12 fishmeal units and also about 476 cold storage units. Processed fish products for export include: conventional block frozen products, individual quick frozen products (IQF), minced fish products like fish sausage, cakes, cutlets, pastes, surimi, texturised products and dry fish etc.

2.11.2 Meat Processing

India has a livestock population of 470 million that includes 205 million cattle and 90 million buffaloes. The country produces about 450 million broilers and 30 billion eggs annually. Animals, which are generally used for production of meat, are cattle, buffalos, sheep and goat, pigs and poultry. Mithun is also slaughtered for meat in North East and Sikkim. Rabbit meat is also used as a specialty in Kerala and some other states.

Consumption per head of both fresh and processed meat in India is very low at 1.5 kilograms. This compares with the world average of 35.5 kilograms. The production of meat and meat products has shown an impressive growth. The details of production of meat and meat products from 1994 to 1998 are as given Table 2.2.

Table 2.2: Production of meat and meat products (in thousand tonnes)

S. No	Meat product	1994	1995	1996	1997	1998
1.	Mutton and Goat Meat	637	647	669	670	675
2.	Pork Meat	366	420	420	420	420
3.	Poultry Meat	422	578	480	580	600
4.	Cattle Meat (Beef)	1290	1292	1202	1292	1295
5.	Buffalo Meat	1200	1204	1204	1205	1210

The total meat production in the country is 4 million tonnes, which includes beef, buffalo meat, mutton, goat meat, pork and poultry meat. However, only about 1% of the total meat is converted into value added products like sausages, ham, bacon, luncheon meat, kebabs, meatballs etc. The total meat export during 1999-2000 was Rs.845.00 crores consisting mostly of mutton and buffalo meat out of which 70% was contributed by export of buffalo meat.

The country has 3600 slaughterhouses, 9 modern abattoirs and 171 meat-processing units licensed under MPO. A few modern pork-processing plants are also coming up in the country. These are primary meat processing houses and are administered by local authorities. Most of them are outdated and use primitive technologies for the production of meat. There are very few modern facilities, although a few such units do exist for pork and bacon processing, for the integrated slaughter and processing of buffalo, sheep and goat meat and for the processing of poultry meat. In addition to this, a large proportion of meat production is slaughtered in houses or small-unlicensed establishments.

Poultry processing is still in its infancy. There are only seven modern integrated poultry processing plants. However, there are a good number of small poultry processing units engaged in production of poultry meat products. There are five egg-processing units engaged in exporting egg products.

The level of processing in the Indian market is very small and the potential for rapid growth is therefore substantial. With the advent of fast food outlets in all the metropolitan centers, the impact on meat processing industry is immense. As per capita incomes rises and urban families live in smaller units, the demand for processed meat products, which can be rapidly cooked, will rise.

2.12 NATIONAL FOOD PROCESSING POLICY

The Government has come out with a draft national food processing policy with a vision to motivate farmers and food processors and to provide interactive coupling between technology, economy, environment and society for steady development of food processing activities to build up a substantial base for production of value added agro food products for domestic and export markets with a strong emphasis on food safety and quality enabling the farmers especially to realize direct benefits of new technology and marketing network and to ensure adequate availability of quality food products for the consumers at affordable prices.

The policy will seek to create an appropriate environment for the entrepreneurs to set up food processing industries through rationalization of tax structure, harmonization & simplification of food laws, promotion campaign to create market for processed foods by providing financial assistance to Industry Associations, NGOs/cooperatives, private sector units, State Government organizations. It also includes infrastructural development programs like establishment of cold chain, low cost pre-cooling facilities near farms, cold stores and grading, sorting, packaging facilities, application of biotechnology, remote sensing technologies, energy saving technologies and technologies for environmental protection, building up a strong infrastructural base for production of value added products with special emphasis on food safety and quality matching international standards etc. The policy has many backward and forward linkages between farmers, market, processors and consumers.

Check Your Progress Exercise 3 ✍

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What is the status and prospects of meat processing industries?

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2. What is National Food Processing Policy?

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2.13 LET US SUM UP

The food industry is divided into production manufacturing distribution and marketing. The industry is highly responsive to change and interrelated with others. Consumers drive the food industry and to some extent the food industry drives the consumer, making changes in food consumption, types and meals. Food is now a global commodity with changing tread scenario in the world.

The food processing industry in India is in its growing stage. It contributes 5.5% of GDP. Most of the foods processing industries are in unorganized sector. There are number of problems which are responsible for slow growth of food Industry. But the prospects of food industry are very good, as changes in the food habits have been observed in the recent past.

Cereal processing is the major food-processing sector in India. Numbers of bakery products are also produced in the India and the market is growing fast rate 7.5% of pulses produced in India is processed for preparation of dall. There are about 5500 processing mills in India. There are about 2.5 lakh *ghanis* in India. Vanaspati production sector is slow. The commercial processing of fruits and vegetables is only 2% in India. There are 5198 food processing units which are registered under food product order.

In fish processing the organized sectors are now coming up. There are about 393 freezing units in the country. Meat is one of the important export commodity in food processing export sector. Only 0.2% of total meat production is further processed at commercial scale. The poultry processing is in the starting phase.

The government has come out with a draft national food processing policy with a vision to motivate and provide interactive compiling between all stakeholders. The policy will seek to create an appropriate environment for the entrepreneurs to set up food processing industries through creating enabling environment, infrastructure development with backward and forward linkages.

2.14 KEY WORDS

National food processing policy : Draft of government on food processing policy of India.

Food processing industries	:	The industries engaged in commercial processing of foods.
Allied industries	:	The industries indirectly associated with food processing industries.
Cereal processing	:	The processing of cereals like wheat, paddy etc.
Primary processing	:	It includes cleaning/grading of raw material and dehusking.
Pulse processing	:	The processing of pulses to get the dall or any other product.
Oilseed processing	:	Processing of oilseeds to extract oil from oil-bearing seeds.
Horticultural crop Processing	:	Processing of fruits and vegetables to increase their shelf life and prepare other products.
HACCP	:	Hazard analysis and critical control points.
Fish processing	:	Processing of fish includes, freezing, canning, deboning etc.

Meat Processing: The processing of animal carcass for human consumption.

2.15 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Your answer should include following points:
   - Classification based on units of industry
   - Classification on food products
2. Your answer should include following points:
   - Past and present status
   - Future prospects and scope

Check Your Progress Exercise 2

1. Your answer should include following points:
   - Problems of farmers, market, processor and consumers
   - Future scope, government policies
2. Your answer should include following points:
   - Cereal, pulses, oilseeds
   - Processing industries, potential

Check Your Progress Exercise 3

1. Your answer should include following points:

   - Meat, fish, poultry processing
   - Present status
   - Future scenario

2. Your answer should include following points:

   - Vision of policy
   - Linkages, creation of enabling environment, infrastructure

2.16 SOME USEFUL BOOKS

1. Economic Survey 2001-2002. Economic Division, Ministry of Finance, Government of India.

2. Fellows, P.J. (1998) Food Processing Technology, Principles and Practices. Woodhead Publishing Limited. Cambridge, England.

3. Parker, R. (2003) Introduction to Food Science. Thomson Learning Inc. New York.

4. Potter, N.N. and Hotchkiss, J.H. (1995) Food Science, 5th Edition. Chapman & Hall Publishing Inc, New York.

UNIT 3 FOOD LAWS AND ASSOCIATED BODIES

Structure

3.0 OBJECTIVES

After reading this unit, you should be able to:

- know types of standards;
- state prevention of food adulteration act (PFA), FPO & MPO, Bureau of Indian standards (BIS), AGMARK standards;
- learn international standards organization (ISO), AOAC, USDA and FDA
- explain codex Alimentarius, HACCP, GMP;
- know about different export promotion councils, APEDA, MPEDA;
- know the organisations - NABL, MFPI, FRAC; and
- organisation describe total quality management (TQM).

3.1 INTRODUCTION

Food processing involves number of unit operations and material handling. So, there are always chances that the food may be contaminated. The food material should also contain essential nutrients. So, standards are formed and number of agencies and organizations are involved at national and international level to make the standards implement and regulate them. This unit covers Indian and international standards and implementing agencies, export promotion agencies of India, NABL, etc. The quality assurance systems like HACCP, TQM and GMP are also covered in brief.

3.2 FOOD LAWS AND STANDARDS

Food is the basic need of all living organisms. Hence, its quality should be given top priority. Processing of the food and food products is usually done at mass scale. So, there are always the possibilities of food being adulterated. The contamination of food can affect a large number of populations at a time and hazards may occur. Secondly, the consumer must get the product for which he has paid. An article of food is called adulterated if the food contains any other substance which effects, or it so processed as to affect injuriously the nature, substance or quality, inferior or cheaper substance has been substituted, prepared and packed or kept under unsanitary condition whereby it has become contaminated or injurious to health, contains filthy, putrid rotten, decomposed or diseased animal or vegetable substance or is insect infested or is otherwise unfit for human consumption etc. The processors may add any prohibited preservative or permitted preservative in excess of the prescribed limits. So, it is essential to set the minimum quantities of desirable characteristics required and the maximum quantities of undesirable components that the food should contain. This also helps to set common standards for commodities and prevents confusion among consumers. Thus, the standards are formulated. There are several ways of arriving at the standards for product quality but four methods are commonly used;

1. **Legal standards:** Standards, which are established by government bodies.
2. **Company or voluntary standards:** Set by the various segments of food industry. Voluntary standards generally represent a consumer image and may become a trademark of product quality.
3. **Industry standards:** An organized group attempts to establish given limits of quality for any food product. Normally these become effective by pressure from marketing organizations or by specific commodity groups where legal standards are not involved.
4. **Consumer or grade standards:** The consumer standards represent the consumer requirements of a product and are generally based on experience of the industry with its consumer.

Out of these, the legal standards are the most important. In fact the government has empowered several agencies and promulgated a number of acts and orders to contract the menace. Agencies and institutions have also been created to lay down standards for the quality of foods. The manner in which the food is processed and packaged is also covered by a number of regulations. Many different types of standards apply to the evaluation, production, testing, and monitoring of dietary supplements. Regulations and product standards are used, as the "yardsticks" that define specific requirements manufacturers must follow to assure product safety and to provide accurate information to health professionals and consumers. These standards also encourage the safety and quality of products by manufacturer making sure that the product meets the standards.

3.3 INDIAN STANDARDS

The Government of India is fully aware of the possibilities of food being adulterated. It has therefore, several agencies, acts, standards and orders which have been formed to formulate standards, implement them, check the adulteration and protect the consumers. Some agencies and institutions were created to lay down standards for the quality of foods. The main agencies involved in this are described below.

3.3.1 Prevention of Food Adulteration Act (PFA)

One of the early acts to be promulgated in food laws and standards was the Prevention of Food Adulteration Act of 1954, which has been in force since June 1,1955, amended 1964 and again in 1976. The objective of this act was to ensure that food articles sold to the customers are pure and wholesome. It is also intended to prevent fraud or deception and encourages fair trade practices.

The Act prohibits the manufacture, sale and distribution of not only adulterated foods but also foods contaminated with toxicants and misbranded foods. A central committee for food standards has been constituted under the Act and has been charged with the function of advising the Central Government on matters relating to the Food standards.

The Food Health Authority is appointed at state level who is the Director of Public Health and Preventive Medicine. He is responsible for the good quality and standards of foods available to the consumers. Under FHA are the Local Health Authority (LHA). There is a Local Health Authority appointed in each city in every state.

3.3.2 Fruit Products Order (FPO)

The Government of India promulgated a Fruit Products order in 1946. In 1955, the order was revised. The Fruit Products Order (FPO) lays down statutory minimum standards in respect of the quality of various fruits and vegetable products and processing facilities. The FPO is enforced by the Department of Health. Presently there is a little over 5198 units registered under the Fruit Products Order of 1955 distributed all over the country. Most of the units fall in the cottage or small-scale sector. A few modern processing plants have, now come up and many more are in the pipeline. The installed capacity which was 11.08 lakh tonnes, in 1993 increased to 21.00 lakh tonnes at the end of the year 1999.

3.3.3 Meat Products Order (MPO)

It provides means to:

1. Detect and destroy meat of diseased animals.
2. Ensure that the preparation and handling of meat and meat products be conducted in a clean and sanitary manner.

3. Prevent the use of harmful substances in meat foods.

4. See that every cut piece of meat is inspected before sale to ensure its wholesomeness.

The order also lays down rules and conditions for the procedure to be adopted for the selection of disease-free animals, slaughterhouse practices.

3.3.4 Bureau of Indian Standards (BIS)

Bureau of Indian Standards (BIS) is the National Standards Organization established as a Society in 1947 as Indian Standards Institution and subsequently made a statutory body as BIS under Bureau of Indian Standards Act 1986. The Bureau comprises of members representing industry, consumer organizations, scientific and research institutions, professional/technical institutes, central ministries, State Government and Members of Parliament. The functions of Bureau are;

1. Standard Formulation.

2. Certification: Product, Quality Management System, Eco Mark, Environment Management System, Hallmarking of Gold Jewellery, Hazard Analysis and Critical Control Points.

3. Laboratory: Testing, Calibration and Management.

4. Standards Promotion.

5. Consumer Affairs.

6. Awareness and Training Programs.

There are 14 Technical departments engaged in formulation of Standards. So far 17000 Standards have been formulated in different technological areas depending upon the National priority. These standards are evolved through the consensus from sectors such as industry, Consumers, testing and laboratory experts and Government organization by co-opting them in the related technical committees, sub committee and panels. The standards are reviewed time-to-time and continuously updated to match the technological changes taking place. The BIS has formulated 1133 standards which pertains to food products.

3.3.5 AGMARK Standard

The AGMARK standard was set up by the Directorate of Marketing and Inspection of the Government of India by introducing an Agricultural Produce Act in 1937. The word ‘AGMARK’ seal ensures quality and purity. The quality of a product is determined with reference to the size, variety, weight, colour, moisture, fat content and other factors are taken into account. It covers the following commodities:

- Pulses
- Cereals, 1966, 2001
- Makhana
- Vegetable oils
- Fruits and vegetables
- Roasted Bengal gram
- Vermicelli, Macroni and Spaghetti

The grades incorporated are grades 1,2,3 and 4 or special, good, fair and ordinary. Any officer of the Central Government or a State Government, or any authority, authorized by the Central Government, may, if he has reason to believe that any provision of this Act or the rules made there under has been, or is being, contravened, enter any premises at any reasonable time and make necessary inspection of, and search for, the agricultural produce in relation which such contravention has been, or is being made. The officer can seize and penalize the firm for not meeting the standards. The Central Government can declare that the provisions of this Act shall apply to an article of agricultural produce not included in the schedule or to an article other than an article of agricultural produce and on the publication of such notification, such article shall be deemed to be included in the schedule.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What do you understand by standards and how they are arrived?

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2. What are the functions of BIS? How standards are formulated?

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3.4 INTERNATIONAL STANDARDS

Quality of food is major concern worldwide. So, each country has formulated its own standards and created agencies for strict quality control measures of the food products. Some of them are internationally accepted as standards. A brief description of some these standards are given in this section.

3.4.1 Association of Official Agricultural Chemists (AOAC)

AOAC is an independent association devoted to promoting methods validation and quality measurements in the analytical sciences. It does this by reviewing and validating approved standard methods of analysis. Promoting uniformity and reliability in statements of results, and developing and promoting criteria useful for laboratory accreditation and analysis certification.

AOAC official methods program is designed to provide methods of analysis for which performance characteristics have been determined and tested. The cornerstone of this program is the inter-laboratory collaborative study by which proposed methods are validated through independent testing in separate laboratories following the same method and analyzing the same samples. The methods can be used to determine compliance with government regulations, to maintain quality control and process requirements, to set and evaluate compliance with terms of procurement contracts, to conduct national and international trade and to support research.

The AOAC methods are recognized worldwide as an authoritative resource, because of thorough and rigorous testing characterization. They are written in U.S. Code of Federal Regulations, Product specifications, and product acceptance, relied on legal proceedings, and required as a basis of national and international trade. They are also adopted by other national and international standards organizations.

3.4.2 United States Department of Agriculture (USDA)

It is the main body of food standards in USA. Regulations and directives are developed by USDA to ensure compliance with all relevant federal laws of USA, executive orders, directives, and policies. It provides links to key Federal Regulations and public laws enacted for USDA food distribution commodity programs and food purchase programs. Regulations and policies of USDA govern food safety related programs, processed product directives, the import and export of meat, poultry, and egg products, and laboratory services. It manages the process of developing food and nutrition regulations and ensures that all the relevant food and nutrition agencies participate in this development process. These regulations provide official marketing standards for grains and oilseeds, and require that exported grains and oilseeds be officially weighed and inspected. The Department's laws also regulate the slaughter and manufacture of meat products. The regulations also protect and promote U.S. agricultural health, administer the Animal Welfare Act, carry out wildlife damage management activities, and ensure that America's agricultural exports are protected from unjustified trade restrictions.

3.4.3 Food and Drugs Administration (FDA)

The Food and Drug Administration of USA is one of the oldest and most respected consumer protection agencies. Its mission is to promote and protect the public health by helping safe and effective products reach the market in a timely way, to monitor products for continued safety after they are in use, and to help the public get the accurate, science-based information needed to improve health. FDA's regulatory approaches are as varied as the products it regulates products such as new drugs and complex medical devices, other products such as x-ray machines and microwave ovens, cosmetics and dietary supplements that must be proven safe and effective before companies can put them in the market. FDA safeguards the USA food supply by making sure that all ingredients used in foods are safe, and that food is free of contaminants like disease-causing organisms, chemicals, or other harmful substances. The agency must approve new food additives before they can be used in foods. It also monitors the safety of dietary supplements and the content of infant formulas and medical foods. FDA regulates all medical devices, including simple items like thermometers to very complex technologies such as heart pacemakers and dialysis machines. However, only the most complex new medical devices are reviewed by the agency before marketing.

3.4.4 International Standards Organization (ISO)

ISO prepared a document called ISO 9000 series in 1987 (modified in 1994) as a guideline for all organizations on managing quality and standard. Its Indian equivalent is IS 14000 (1988). It is the principle and criteria for a management system, which will improve a company's performance. It is a media for ensuring orderly and systematic maintenance and upkeep of system. It covers quality, quality policy, quality management, quality system, quality control, quality assurance, quality improvement, product, service, process and customer. The ISO series is given below;

ISO 9000-1,2,3,4	:	Quality management and quality assurance
ISO9004-1:		Quality management and quality system elements subcontractor
ISO9004-2:		Guidelines for services
ISO9004-3:		Guidelines for processed materials
ISO9004-4:		Guidelines for quality improvement
ISO9004-5:		Guidelines for project management
ISO9004-6:		Guidelines for quality plans
ISO9004-7:		Guidelines for configuration management
ISO 10011-1,2,3	:	Guidelines for auditing quality system
ISO 10012-1,2	:	Quality assurance requirements for measuring equipment
ISO 10013:		Guidelines for developing quality manual
ISO 10014:		Guidelines for economic effect of quality
ISO 10015:		Continuing education and training guidelines

3.4.5 Codex Alimentarius

The term Codex Alimentarius is taken from Latin and means food code. The FAO/WHO Codex Alimentarius Commission was established to implement the joint FAO/WHO Food Standard Program. About 150 countries including India are member of the commission. The purpose of this program is to protect the health of consumers and to ensure fair practice in the food trade; to promote coordination of all food standards work undertaken by international governmental and non-governmental organizations; to determine priorities and initiate and guide the preparation of draft standards through and with the aid of appropriate organizations; to finalize standards and after acceptance by Governments, publish them in a Codex Alimentarius either regional or worldwide standards. It brings together all the interested parties -scientists, technical experts, governments, consumers and industry representatives to help develop standards for food manufacturing and trade. These standards, guidelines and recommendations are recognized worldwide for their vital role in protecting the consumer and facilitating international trade. As Codex Alimentarius represent a consensus of food and trade experts from around the world, these standards are more and more being used in international trade negotiations and also for setting of disputes by WTO.

The Codex contract Point in India is the Directorate General of Health Services (DGHS) in the Ministry of Health. Ministry of Food processing Industries is also closely associated with the activities of Codex Alimentarius.

3.4.6 Hazard Analysis and Critical Contort Point (HACCP)

Hazard Analysis and Critical Control Point (HACCP) is an important quality assurance system. This system ensures that the products are safe and have good quality. The system is extremely desirable in view of the changing scenario in the International trade. It is science based and systematic, identifies specific hazards and measures for their control to ensure the safety of food. HACCP is a tool to assess hazards and establish control systems that focus on prevention rather than relying mainly on end product testing. The system is capable of accommodating changes such as advances in equipment design, processing procedures or technological developments. It can be applied throughout the food chain from primary production to final consumption and its implementation should be guided by scientific evidence of risk to human health. The application of HACCP is compatible with the implementation of quality management systems, such as ISO 9000 series and is the system of choice in the management of food safety within such systems. The HACCP system consists of following seven principles;

1. Conduct a hazard analysis.
2. Determine the Critical Control Points (CCPs).
3. Establish critical limits.
4. Establish a system to monitor control of CCP.
5. Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control.
6. Establish procedures for verification to confirm the HACCP system is working effectively.
7. Establish documentation concerning all procedures and records appropriate to these principles and their application.

Prior to application of HACCP to any sector of food chain, the sector should be operating according to Codex General Principles of Food Hygiene, the appropriate Codex Codes of Practice, and appropriate food safety legislation. During hazard identification, evaluation and subsequent operations in designing and applying HACCP systems, consideration must be given to the impact of raw materials, ingredients, food manufacturing practices, role of manufacturing processes to control hazards, likely end use of the product, categories of consumers of concern and epidemiological evidence relative to food safety. The application of HACCP principles consists of following tasks;

1. Assemble HACCP team. The team must comprise of all experts required for the development of an effective HACCP plan for a specific food commodity.
2. All the information of the product such as composition, physical/ chemical structure treatments etc should be described.
3. The intended use should be identified. It should be based on uses of the product by the end user or customer.

4. The HACCP team should construct a flow diagram covering all the steps in the operation.

5. On-site confirmation of the flow diagram should be done and amendments in the flow diagram should be done if required.

6. All the hazards associated with each step should be listed, a hazard analysis should be conducted and controls measures should be considered for identified hazards.

In a large food factory the team should be multi-disciplinary that is, it should include a microbiologist, processing specialist, chemist, biochemist, engineer, packaging technologist, sales and training staff and personnel managers. For medium and small scale, the quality control and production managers and few supporting staff like sales and administrative managers should be enough.

3.4.7 Good Manufacturing Practices (GMP)

GMP provides quality assurances that off-the-shelf testing cannot. It provides continual measures of quality that can uncover problems and fluctuations as they occur before the product is shipped. The need for GMP takes on further importance because the issues involved in developing test methods for dietary supplements are many and complex. Until methods are further developed, standardized, and widely accepted, GMP serves as a primary vehicle for ensuring quality.

Good manufacturing practices (GMP) lie at the heart of quality. GMP comprise a variety of practices that ensure quality including things such as:

- Raw materials quality assurance
- Record-keeping of substances throughout the manufacturing process
- Standards for cleanliness and safety
- Qualifications of manufacturing personnel
- In-house testing
- Production and process controls
- Warehousing and distribution

Virtually every manufacturer adheres to an in-house GMP standard, which varies from producer to producer. In-house GMP, while often extremely effective, does not provide a means for outside verification of quality. In order to provide such verification, many are now embracing to industry-standard GMP that is usually subject to an independent outside audit for compliance.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Differentiate AOAC, USDA and FDA.

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2. What do you understand by HACCP? How quality assurance is achieved through it?

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3.5 EXPORT PROMOTION COUNCIL

The Export Promotion Council has been constituted to check the quality of a number of food materials meant for export. The council has powers to reject any food item, which does not measure up to the standards prescribed for the food. Federation of Indian Export Organizations (FIEO) is the apex body of all Export promotion councils/Commodity Boards/Export Development Authorities in India. There are 25 boards and export development authorities. The main work of these authorities is to promote the export, assure the quality of the product the international standards, formulate the standards for export etc. List of export councils related to food products are given below.

1. Agricultural and Processed Food Products Export Development Authority (APEDA)
2. Cashew Export Promotion Council of India
3. Coffee Board
4. Marine Products Export Development Authority (MPEDA)
5. Shellac Export Promotion Council
6. Spices Board
7. Tea Board
8. Tobacco Board
9. Wool and Woollen Export Promotion Council

3.6 APEDA AND MPEDA

3.6.1 Agricultural and Processed Food Products Export Development Authority (APEDA)

APEDA is an autonomous organization attached to the Ministry of Commerce of the Government of India. The main function of APEDA is to build links between Indian producers and the global markets. APEDA undertakes the briefing of potential sources on government policy and producers along with providing referral services and suggesting suitable partners for joint ventures besides arranging buyer-seller meets. It also provides recommendations to the Trade and Industry.

APEDA offers financial assistance under various schemes, which seek to promote and develop agro exports. Financial assistance under these schemes is available to exporters, growers, and trade associations, governmental agencies.

3.6.2 Marine Products Export Development Authority (MPEDA)

The Marine Products Export Development Authority (MPEDA) was constituted in 1972 under the Marine Products Export Development Authority Act 1972. The role envisaged for the MPEDA under the statute is comprehensive covering fisheries of all kinds, increasing exports, specifying standards, processing, marketing, extension and training in various aspects of the industry.

MPEDA functions under the Ministry of Commerce, Government of India and acts as a coordinating agency with different Central and State Government establishments engaged in fishery production and allied activities. The plan schemes of the Authority are implemented under four major heads:

1. Export production - Capture Fisheries
2. Export production - Culture Fisheries
3. Induction of New Technology and Modernization of Processing Facilities.
4. Market Promotion

It implements developmental measures vital to the industry like distribution of insulated fish boxes, putting up fish landing platforms, improvement of peeling sheds, modernization of industry such as upgrading of plate freezers, installation of IQF machinery, generator sets, ice making machineries, quality control laboratory etc.

3.7 FOOD HEALTH AUTHORITY

The Food Health Authority is appointed at state level that is the Director of Public Health and Preventive Medicine. It is responsible for the good quality and standards of foods available to the consumers. Under FHA is the Local Health Authority (LHA). There is a Local Health Authority appointed in each city in every state. The food Inspector is appointed by the Central or State Government by notification in official gazette. The main work of this authority is to take a random sample of any food article from any person selling such article, or who is in the course of delivering or preparing to deliver such article to a purchaser or consignee or a consignee after delivering of any such article to him. Then these samples are sent for analysis to the Public Analyst (PA) of local area.

3.8 NATIONAL ACCREDITATION BOARD FOR TESTING AND CALIBRATION LABORATORIES (NABL)

The concept of Laboratory Accreditation was developed to provide a means for third-party certification of the competence of laboratories to perform specific type(s) of testing and calibration. Laboratory Accreditation provides formal recognition of competent laboratories, thus providing a ready means for customers to find reliable testing and calibration services in order to meet their demands. It enhances customer confidence in accepting testing / calibration reports issued by accredited laboratories.

National Accreditation Board for Testing and Calibration Laboratories (NABL) is an autonomous body under the aegis of Department of Science & Technology, Government of India, as a registered Society. NABL has been established with the objective to provide Government, Industry Associations and Industry with a scheme for third-party assessment of the quality and technical competence of testing and calibration laboratories. Government has authorized NABL as the sole accreditation body for Testing and Calibration of laboratories.

NABL provides laboratory accreditation services to laboratories that are performing tests / calibrations in accordance with ISO/IEC 17025. These services are offered in a non-discriminatory manner and are accessible to all testing and calibration laboratories in India and abroad, regardless of their ownership, legal status, size and degree of independence.

NABL has established its Accreditation System in accordance with ISO/IEC Guide. In addition NABL has to also comply with the requirements of APLAC MR001, which requires the applicant and the accredited laboratories to take part in recognized Proficiency Testing Programs in accordance with ISO/IEC Guides. NABL has been conducting Proficiency Testing with the help of selected accredited laboratories as nodal laboratories in different fields.

NABL accreditation is a formal recognition of the technical competence of a testing or calibration laboratory for a specific task following ISO/IEC 17025 Standard. This is based on third party assessment.

NABL Accreditation is currently given in the following fields:

Testing laboratories	Calibration Laboratories	Clinical Laboratories
• Biological • Chemical • Electrical • Electronics • Fluid-Flow • Mechanical • Non-Destructive • Photometry • Radiological • Thermal	• Electro-Technical • Mechanical • Fluid Flow • Thermal & Optical • Radiological	• Clinical Biochemistry • Clinical Pathology • Haematology • Microbiology and Serology • Histopathology • Cytopathology • Cytogenetics • Immunology • Nuclear Medicine • Blood bank and transfusion services

3.9 FOOD RESEARCH AND ANALYSIS CENTER (FRAC)

The Food Research and Action Centre (FRAC) is a leading national organization working to improve public policies to eradicate hunger and under-nutrition in the United States. Founded in 1970 as a public interest law firm, FRAC is a non-profit and non-partisan research and public policy centre that serves as the hub of an anti-hunger network of thousands of individuals and agencies across the country.

- FRAC engages in a variety of activities at the national, state and local levels to form a comprehensive strategy for reducing hunger in this country.

3.10 MINISTRY OF FOOD PROCESSING INDUSTRIES (MFPI)

The Ministry of Food Processing Industries, set up in July 1988, is the main central agency of the Government of India responsible for developing a strong and vibrant food processing sector; with a view to create increased job opportunities in rural areas, enable the farmers to reap benefit from modern technology, create surplus for exports and stimulating demand for processed food. The subjects looked after by the Ministry are:

- Fruits and vegetable processing industry
- Food grain milling industry
- Dairy products
- Processing of poultry and eggs, meat and meat products
- Fish processing
- Bread, oilseeds, meals (edible), breakfast foods, biscuits, confectionery (including cocoa processing and chocolate), malt extract, protein isolate, high protein food, weaning food and extruded/other ready to eat food products
- Beer, including non-alcoholic beer
- Alcoholic drinks from non-molasses base
- Aerated waters / soft drinks and other processed foods
- Specialized packaging for food processing industries

The scope of the Ministry has been very much enlarged. It includes development of fruit &. Vegetable processing and promote food-grain milling including dairy products and processing of poultry, eggs & meat products. Processing of fish including canning & freezing and technical assistance to the industry also form a very important part of its activity. In addition planning & developing of industries relating to bread, oilseeds, breakfast food, biscuits, confectionery specialized packaging, including non-alcoholic beer, aerated drinks also fall within the scope of this Ministry.

3.11 TOTAL QUALITY MANAGEMENT

Total Quality Management is a process, which explores the formation of management and employees into a “team-concept” approach to production of quality products. It is a structured system for satisfying internal and external customers and suppliers by integrating the business environment, continuous improvement, and breakthroughs with development, improvement, and maintenance cycles while changing organizational culture.

One of the keys that are most important to the successful implementation of Total Quality Management is the idea that it is a structured system. It is basically a strategy derived from internal and external customer and supplier wants and needs that have been determined through daily management. The implementation of Total Quality Management requires the help of the following eight key elements.

1. Ethics
2. Integrity
3. Trust
4. Training
5. Teamwork
6. Leadership
7. Communication
8. Recognition

Total Quality Management is built on a foundation of ethics, integrity and trust. It fosters openness, fairness and sincerity and allows involvement by everyone.

3.12 PRODUCT CERTIFICATE AND LICENSING

Product certification and licensing in India is done by number of organization. BIS operate product certification under the rules and regulation of BIS Act 1986. A manufacturer is granted license to use the standard mark after assessment of his infrastructure facilities for manufacturing and quality control checks to produce goods in consistent with quality control. The conformity to standard is further ensured by regular surveillance at licensee's performance by surprise inspections and testing of samples from the factory and market. BIS offers certification schemes to food industries on

1. Food safety certification against IS 15000:1998

2. HACCP based quality system certification for two certification

   a) Audit certification of quality system against IS/ISO 9000, and
   b) Certification of HACCP against IS 15000:1998.

The BIS has brought 1435 items and over 7500 factories under its fold. Items affecting health and safety of consumer have been enforced through compulsory certification. In 1991 Government of India introduced "ECO" mark for environmentally friendly products.

The Directorate of Marketing and Inspection (DMI) issues "AGMARK" certificate to the notified food products. It enforces the Agriculture Produce Grading and Marketing Act 1937. Grading under this provision is voluntary. It involves sorting of commodities according to their quality followed by inspection to verify the correctness of grade assigned to them. It is also enforcing MPO.

Ministry of Civil Supplies, Consumer Affairs and Public Distribution is responsible for standardization of weight and measures. They regulate the quality of the vanaspati vegetable oils and fats through solvent extraction plants. The new act contains provision for regulation to pre-packed commodities, which are intended to establish fair-trading and price discipline for commodities sold to consumers in packed form with levelling.

For export materials, APEDA issues the certificate. . The authority feels that the products complying with the basic quality and safety requirements should carry a mark that remains sacrosanct across categories and communicates the adherence to quality assurance measures. With this in view, a system for grant of the Certification mark i.e. "Quality Produce of India" has been developed by APEDA for agricultural products being exported. The Certification Mark will be granted on the basis of compliance with hygiene standards, implementation of Quality Assurance System such as ISO 9000, Food Safety System such as HACCP, backward linkage, residue testing of pesticides and contaminants, laboratory facilities and nature of complaint etc. Initially, the proposal is to launch this scheme for few products like meat, rice, fruits and vegetables. This Certification Mark is owned by APEDA. Only such exporters whose produce/ products conform to the prescribed parameters are allowed/ licensed to use the trademark for exports.

Check Your Progress Exercise 3 ✍

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are APEDA and MPEDA and what are their functions?

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2. Why accreditation is required? Define the role of NABL.

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3. What do you understand with Total Quality Management?

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3.13 LET US SUM UP

Consumers expect certain qualities from their food. To arrive the quality character tics, different types of standards are made. Food science determines and uses methods to measure food quality factors. Number of agencies and organizations are involved at national and international level to make the standards implement and regulate them.

PFA is implemented in 1955 to ensure that food articles sold to the consumers are pure and wholesome. FPO and MPO were also enforced to lay down statutory minimum standard for fruits, vegetables and meat. BIS is a body responsible for laying down policy guidelines for formulating standards.

International agencies like AOAC are involved in promoting methods validation and quality measurement of food products. USDA and FDA are the agencies for formulating and implementing standards. ISO is the organization on managing quality and standards codex Alimentarius was established to implement the food standard programme into member countries in post WTO era. HACCP and GMP are quality assurance systems.

Different export promotion councils are constituted in India to promote export like APEDA, MPEDA etc. NABL was developed to provide means for ratification of the competence of laboratories to perform specific type of works. MFPI is the main control agency in India for food processing.

3.14 KEY WORDS

AOAC : Abbreviation for Association of official Analytical chemists.

Certificate : A document providing evidence of status of qualification.

Critical control point : Any point in the process where loss of control may result in a heath risk.

Food safety : A judgment of acceptability of the risk involved in eating a food; of risk is relatively low, a food substance may be considered.

GMP : Good manufacturing practices guidelines that a company uses to evaluate the design and constriction of food processing plants and equipment.

HACCP : Hazard Analysis Critical Control Point; a preventive food safety system.

Standards : Set up and established by authority as a rule for the measure of quantity, weight, extent, value, or quality. Set by different agencies to specifically describe a food; to be labelled as such, a food must meet these specifications.

TQM : Total quality management.

NABL	**:**	National Accreditation Board for Testing and Calibration Laboratories.
FRAC	**:**	Food Research and Analysis Centre, an organization to improve public polices in USA.

3.15 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Your answer should include following points:

   - Definition
   - Legal, company, industry, and consumer standards

2. Your answer should include following points:

   - BIS
   - Function of BIS
   - Formulation process

Check Your Progress Exercise 2

1. Your answer should include following points:

   - Associations information, functions
   - Status and regulations

2. Your answer should include following points:

   - Quality assurance system, need
   - Principles, tasks

Check Your Progress Exercise 3

1. Your answer should include following points:

   - Purposes, structure
   - Functions

2. Your answer should include following points:

   - Concept of accreditation
   - Need, functions of NABL

3. Your answer should include following points:

   - Need, importance
   - Key elements

3.16 SOME USEFUL BOOKS

1. Fellows, P.J. (1998) Food Processing Technology, Principles and Practices. Woodhead Publishing Limited. Cambridge, England.

2. Parker, R. (2003) Introduction to Food Science. Thomson Learning Inc. New York.

3. Potter, N.N. and Hotchkiss, J.H. (1995) Food Science, 5th Edition. Chapman & Hall Publishing Inc, New York.

4. Potter, N.N. (1987) Food Science. S.K. Jain for CBS Publishers & Distributors, New Delhi.

UNIT 4 FOOD GRAINTS, PULSES AND OIL SEEDS

Structure

4.0 OBJECTIVES

After reading this unit, you should be able to:

- explain importance of cereals pulses and oil seeds in our day-to-day requirement and to national economy;
- state the important properties and primary processing methods to make them edible and their storage; and
- describe value added products and Utilization of by products of cereals, pulses and oilseeds.

4.1 INTRODUCTION

Food grains play a major role in the Indian economy as they meet our food and fiber requirements. Food grains are the basic need of day-to-day requirement of human life. With the increase in population and awareness, every human being need right quality of foodstuff at the right time. It is also our duty that the cost of the foodstuff to meet the basic need should be affordable to every one. Agricultural produce are seasonal, weather dependent thus their storage for whole year and some times more than a year is required. During the storage, the quality of the foodstuff should not deteriorate. Most of the agricultural produce (cereals, pulses and oil seeds) is not consumed as they are produced. These produce need to be processed. The processing should be economically viable and the loss of energy and nutrition should be the least. Therefore, knowledge of appropriate machines and process is must.

Food processing industries have enormous significance in the national development through linkage between two main pillars of economy namely industry and agriculture. Growth of food processing industry means raising agricultural yield and creating rural employment. It leads to rise in the economic standard of large number of people through out the country.

4.2 PRODUCTION AND IMPORTANCE

Agricultural production in India has travelled a long way in the post independent era from scarcity to surplus. After green revolution the country has become not only self-sufficient but also surplus in food grain production. Now the country is producing about 200 million tonnes of food grains (90 million tonnes of paddy, 75 million tonnes of wheat and other coarse grains) 15 million tonnes of pulses and 23 million tonnes of oil seeds. In spite of such huge production, our population have per capita availability is less than the dietary requirement given by Indian Council of Medical Research. Therefore, nation has to import edible oil from other countries.

Post harvest technology of food grains have also had a paradigm shift in the last 50 years. At the time of independence most of post harvest operations were carried out by small scale processing units. These units were operated by human or animal power. There recovery was less and losses were high. Now many modern processing units comprising primary to tertiary processing are working. These units not only process the material but also process the byproducts into value added products.

4.3 STRUCTURE AND COMPOSITION

Wheat is a single seeded fruit consisting germ and endosperm enclosed by epidermis and seed coat. Paddy, pulses and other crops consist an outer husk cover in addition to above parts. The husk consists of silica acts as a barrier to moisture migration, insect infestation and fungal damage.

The germ is the principal part of the seed. It is rich in fat and is heat sensitive. The endosperm is full of starch granules and works as reservoir of food for developing embryo.

The chemical composition of the seed is widely dependent upon the environment in which crop is produced, the variety, soil and fertilizer application. In general, cereals are rich in carbohydrate; pulses are in protein and oilseeds in fats and lipids. The proximate composition of important cereals, pulses and oilseeds are given in Table 4.1. In general outer layers (pericarp) contains cellulose, endosperm is rich in carbohydrate and small amount of proteins, germ contains the highest amount of fat, protein, enzyme and small amount of sugars.

Protein present in the cereals gets denatured above 50^{o}C. Thus, their water absorbing and swelling capacity decreases. It affects the quality of dough. The starch is insoluble in cold water. Its quality is not affected even if the temperature is raised to 60^{o}C. However, at temperature higher than 70^{o}C geletinization of starch takes place. It leads to deterioration in the colour. Fats are heat resistant up to an extent. However, at higher temperature (above 70^{o}C) partial decomposition starts and increases the acid numbers. Vitamins present in the germ are destroyed with the heat treatment.

4.4 POST HARVEST LOSSES

With the green revolution and support of farmers the country has increased its food grains production to four fold between 1950's and 1970's. Though the rate of increase in production has declined after 1980's but still it is more than our country's requirement. It is also estimated that about 8 to 12% of the produce is lost in various post harvest handling and storage practices. The loss amounts to be Rs. 20,000/- crores annually.

The traditional processing of dal and oilseeds results in poor recovery. In most of the pulse mills in India has the dal recovery of 65 to 70 % against maximum possible recovery of 81 to 84 %. Similarly oil remains in the residual oil cake which is about 10 to 15 % of total available oil in the oilseed.

The maximum loss of food grain occurs during storage. As you know, in India major portion of food grains (more than 75%) is stored in large number of small capacity rural godowns. These godowns have free access to insect-pest, rodents and also affect the quality of the grains by the change of environment. It is estimated that in some of the godowns the losses are as high as 30 % in humid region if grains are stored for 8-10 months.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Name two main pillars of Indian economy.

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2. "Whole world is looking towards India as a big market". Give reasons?

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3. List the factors, which affects the chemical composition of the grains?

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4. What happen to the solubility of starch when temperature increases?

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5. Post harvest losses in the pulses are mainly during ………………………...

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Table 4.1: Average composition of food grains, pulses and oil seeds

Commodity	Moisture (%)	Calories (Cal/ 100g)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Mineral (%)	Thia-mine (mg/ 110g)	Ribo-flavin (mg/ 100g)	Niacin (mg/ 100g)
Wheat	12.5	330	12.3	1.8	2.3	1.7	1.5	0.52	0.12	4.3
Paddy	12.0	360	7.5	0.9	0.9	1.2	0.7	0.34	0.05	4.7
Corn	13.8	348	8.9	3.6	2.7	1.2	1.5	0.37	0.12	2.2
Bajra	12.4	360	9.5	5.0	1.2	2.5	2.7	0.73	0.38	2.3
Ragi	13.1	332	7.1	1.3	3.3	2.7	2.0	0.42	0.12	1.1
Bengalgram	9.8	361	17.1	5.3	3.9	-	2.7	0.45	0.21	2.6
Blackgram	10.9	350	24.0	1.4	-	-	3.4	0.45	0.22	2.0
Cowpea	12.0	327	24.6	0.7	3.8	-	3.2	0.50	0.21	1.5
Greengram	10.4	350	24.0	1.3	-	-	3.6	0..46	0.21	2.0
Soyabean	8.1	432	43.2	19.5	3.7	-	4.6	0.73	0.32	2.4
Mustard	7.9	549	26.7	40.1	4.1	-	1.9	0.90	0.13	14.1

Source: NIN, ICMR, Hyderabad 1999

4.5 PHYSICAL AND THERMAL PROPERTIES

The knowledge of properties of grains such as size, shape, surface area, different densities, colour, frictional properties, thermal properties, diffusivity, equilibrium moisture content etc. are important for designing the various post harvest handling, storage, separation and drying systems. Some of the properties are discussed hereunder in this unit.

- Physical properties
- Thermal properties

4.5.1 Physical Properties

Accurate measurement of size and shape of the individual grain are important engineering data. These data helps in designing of machines for the post harvest handling and processing. The size and shape of the grain helps in designing cleaner, grader and if grains are to be passed between two rollers for shelling, milling or crushing. The terminal velocity of the grain helps in designing pneumatic conveyor, winnower etc. The geometry of the grain provides the surface area, which helps in moisture migration (absorption or drying). In general three major axis are measured and denoted as dimension a, b and c of the grain. **The sphericity** is defined as the ratio of geometric mean of 3-major axis to the largest axis dimension. It represents degree of closeness of the grain with the sphere.

$$\text{Size of the grain} = (a \times b \times c)^{1/3}$$

$$\text{Sphericity of the grain} = (a\ b\ c\ )^{1/3} / a$$

Where, a: is the largest dimension of the grain.
b: is the medium dimension perpendicular to the largest dimension of the grain.
c: is the smallest dimension perpendicular to above two of the grain.

Some dimensions and sphericity of the grains is given in **Table 4.2**

Table 4.2: Major dimensions and sphericity of the grains

Grains	Longest dimension (a) (mm)	Medium dimension (b) (mm)	Smallest dimension (c) (mm)	Sphericity $\frac{(abc)^{1/3}}{a}$
Rice, IR-8	8.68	3.02	1.97	0.427
Wheat, PB593	6.43	3.55	3.09	0.652
Maize, Ganga 5	8.92	8.33	6.89	0.901
Bengal gram	8.56	6.25	5.96	0.801
Black gram	4.87	3.90	3.37	0.762
Green gram	3.86	3.18	3.11	0.865
Pea,VRS-6115	6.89	6.43	6.04	0.945
Pigeon pea	6.56	5.30	4.63	0.895
Groundnut kernel	14.45	8.74	7.50	0.685
Soya bean	7.02	6.29	5.05	0.874

Source: Engineering Properties of Food Materials (1980) CIAE, Publication /80/15

The bulk density, specific gravity and porosity plays an important role for designing the storage structures, specific gravity separator, pneumatic conveyor and other handling equipments. The bulk density is defined as the weight of grains per unit volume. The specific gravity is defined as the ratio of true density (mass of the grains per unit solid volume) to the density of water. The true density of the grains is calculated by fluid displacement method using **pycnometer.** The density of the grains varies with the variety and moisture content. The porosity is calculated from the true and bulk density of the grains. The porosity is affected by degree of compaction. Some properties of the grains are given in Table 3.

Angle of repose and frictional properties of grains plays an important role in designing hoppers, discharge chutes, elevators, dryers, storage bins and other equipments for grain flow and handling. The frictional coefficient depends upon the shape of the grain, surface characteristics and moisture content of the grains. **The angle of repose** of the grains is the angle between the base and the slope of the cone formed, when grains are freely dropped on the horizontal plane. The frictional properties and angle of repose of some grains are given in Table 4.3.

Table 4.3: Some physical and mechanical properties of the grains

Grains	Moisture content (%, wb)	Bulk Density (Kg/m^3)	True Density (Kg/m^3)	Porosity	Angle of repose (Degree)	Friction coefficient on sheet metal
Wheat	8-14	790-700	1390-1400	40	26-28	0.40
Rice	9-11	610-580	1200-1240	54	27-30	0.48
Corn	10	820	1393	41	26-28	0.23
Soya bean	10-11	680	1180	42	24-25	0.34
Pigeon pea	9-10	815	1330	39	19	0.29
Gram	8-9	815	1340	39	17	0.35

Source: Engg. properties of Food material (1980) CIAR Publication /80/15

4.5.2 Thermal Properties

Cereals, pulses and oilseeds are harvested at higher moisture content in order to reduce shattering losses and safety against untimely rains or weather. These grains are to be dried to safe moisture level for marketing, processing or storage. For that heating, drying and cooking may be involved. Therefore, thermal properties namely, conductivity, diffusivity etc are required to be known for designing the dryers, cookers etc. Thermal properties of some grains are given in Table 4.4.

Table 4.4: Thermal properties of grains

Grains	Moisture content (%, db)	Specific heat (KJ / Kg K)	Thermal conductivity (W / m K)	Thermal Diffusivity (10^{-7} m^2 /s)
Wheat	10-20	1.09	0.139	0.91
Rice	10-20	1.33	0.087	1.00
Corn	10-20	1.20	0.165	0.89
Pigeon pea	8-22	1.50	0.153	0.94
Soyabean	8-10	2.01	0.116	0.54
Bengal gram	10-20			17.1
Mustard	8-12	2.56	0.175	0.73
Sorghum	8-12	1.69	0.124	0.85

Source: Engg. properties of Food materials (1980) CIAE Publication /80/15

4.6 WATER ACTIVITY

Water activity is an important characteristic of food grains. It influences odour, flavour, texture, colour, enzymatic activity and microbial load on the food product. Therefore, for safe keeping the food grains its knowledge and relationship with the atmosphere is must.

Water activity is a ratio of partial vapour pressure in a food product over the equilibrium vapour pressure of the product at the same temperature. In general for safe storage of food grains water activity should be below 0.6. However, to avoid lipid oxidation (which leads to rancidity in fats) water activity should be below 0.3. The most congenial atmosphere for growing the bacteria is when water activity is above 0.8 and for yeast and molds above 0.7.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Why do we require to measure the size of the grains?

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2. Name two machines in whose designing terminal velocity is used?

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3. Define angle of repose of the grains.

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4. Name the instrument used for measurement of true density of the grains.

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5. List the characteristics of the grain influenced by the water activity of the storage.

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6. For safe storage of oil seeds, what is the water activity recommended.

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4.7 CLEANING AND GRADING

Cleaning is the first unit operations in any grain-processing unit. As the name explains, the purpose is to remove unwanted materials like chaff, stone, dust, and metallic pieces. In general, it is done with the set of sieves arranged one above other. The top sieve will have openings just equal to the size of the grains. The impurities bigger than the grain size are rolled above the screen and discarded. The grains and smaller impurities pass through the first sieve; fall on the second sieve, which have the openings smaller than the grain size. Here dust and smaller impurities pass through the sieve and collected separately. Clean grains roll over the screen and are collected. In general a fan is also attached with the cleaner. The fan blows/sucks the sufficient air to throw/carry away the finer impurities of the grains. Usually fan blows the air beneath the sieve. Thus, it helps in cleaning the screen to avoid choking of sieves. An oscillating screen cleaner with aspirator is shown in Figure 4.1.

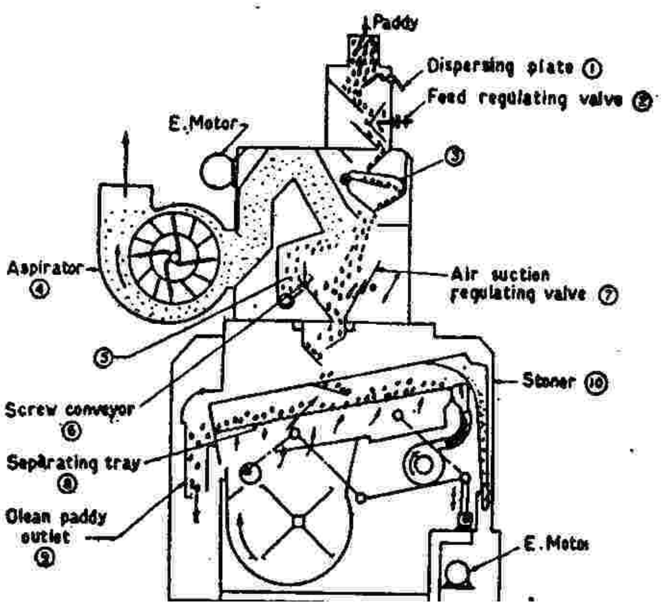

Figure 4.1: Oscillating screen cleaner with aspirator

In some cleaners, near the discharge end, a magnet is fitted. This magnet attracts the metallic impurities, which are removed manually at short intervals. Sieves may have round, oblong, rectangular or triangular openings depending on the requirement of the grains (Figure 4.2). In most of the cleaners, sieves are changeable to accommodate large variety of grains for cleaning. The oscillation speed of the sieve, feed rate and impurities composition decides the performance of the cleaner. In the modern cleaner, screen-cleaning brushes are fitted, which clean the screen to overcome problem of choking. Higher airflow of fan may carry away the grains and lower airflow may leave the impurities in the grain. So airflow based on terminal velocity of grains must be used.

Grading of grains is necessary as it aids to the value of the grains and helps in improving the performance and efficiency of processing machines. Grains, which are produced and harvested in the field, vary in their appearance, size, and location in the plant within the farm. If seeds sown are mixture of few varieties, the final produce may differ in the grain characteristics. The grading is defined as separation of the mixture in to separate sections based on their common quality characteristics. Grading is done based on size, wholesomeness of the grain, test weight, varietal purity, oil content, protein content, colour, hardness etc.

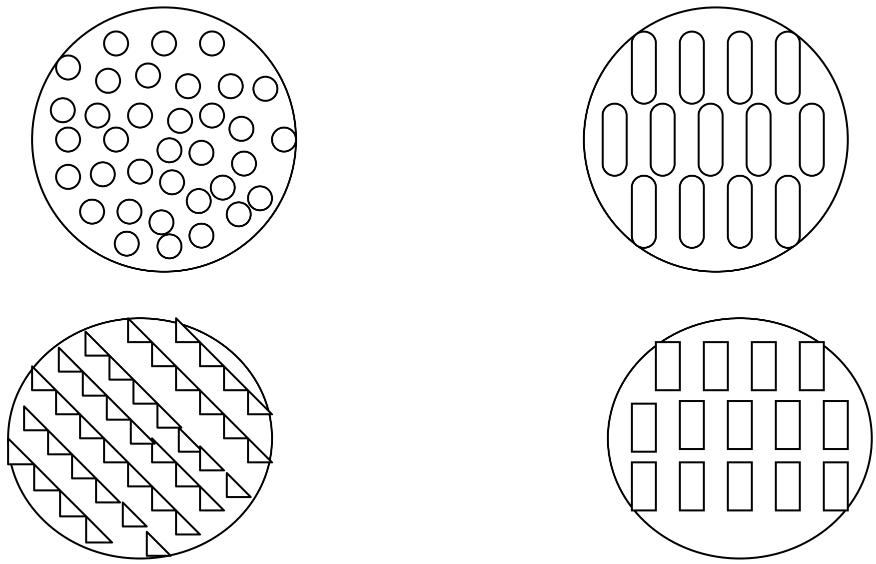

Figure 4.2: Different types of perforation on the sieve

4.8 PARBOILING CONDITIONING AND DRYING

Parboiling

Parboiling is a hydrothermal treatment given to grains specially paddy and wheat in order to make grain harder. In paddy, rice kernel become harder so that it could withstand the milling stresses and result in higher head yield. Parboiling is conducted in three steps namely soaking, steaming and drying. Soaking of paddy in the traditional method is done for 24 to 72 hours at the ambient temperature depending up on weather. In the modern method, soaking is done at 70^{o}C for 3½ hours. The void space between husk and kernel is filled with the water and moisture content of the grain is raised to 30% wet basis. After draining the excess water soaked paddy is steamed for 20-30 minutes. The moisture content of paddy is increased to 35% wet basis. Then paddy is dried to 14% moisture content. Traditional parboiling method has prolonged soaking, which imparts deep colour to the rice, off flavour, and some times in rainy season mold growth on the grains. In the modern parboiling method some of these defects are eliminated. In the process of soaking and steaming rice starch get gelatinized, protein get expanded and occupies the air space with in endosperm. It increases the cohesion and adhesion between starch granules and protein bodies. It also checks the cracks in rice kernel and it become stronger to withstand milling stresses.

During the process of parboiling vitamins of outer layer moves inside starchy endosperm and oil globules moves outside in the bran layer. Thus, after milling parboiled rice has more vitamins than raw rice and its bran has move oil content than raw rice bran. It is also found that due to heat treatment total water uptake, swelling index of parboiled rice is more than raw rice. Energy required in dehusking and loss of solids in the gruel is less in parboiled rice. The total rice turn out of parboiled rice is 70-73% which is 2-8% higher than raw rice and whole rice turn out is 60-65% which 20-30% more than raw rice.

Conditioning

Conditioning of grains specially pulses and oilseeds is done in order held or get better dal and oil recovery. Pulses are scratched, smeared with oil and water, dried in order to loosen the husk. Oilseeds are smeared with hot water prior to crushing to improve the oil recovery. Excess of wetting and drying of pulses affects their cooking quality as protein enclosed in the complex form, which changes its behaviour when hydrated and dehydrated.

Drying

Drying of grains is an important unit operation as it affects the ultimate quality of the grains. Grains {cereals 12-14%, pulses 10-12% and oil seeds 8-10%} moisture content is considered to be safe for storage.

Traditionally grains are dried in the drying yard with sun's energy. The grains are spread 5-10 cm thick layer and frequently turn to have uniform drying.

The limitations of the sun drying are:

- Weather dependent process
- Require more human energy for turning during drying
- Non-uniform drying
- Slow drying affects the quality of the product and increases the microbial load on the grains.

Thin layer drying through mechanical dryers with 10-15 cm thickness of the grain layer are the most common dryers used in the grain processing industry. Burning agricultural waste generates the heat, which is passed through heat exchanger. The hot air is blown and mixed with a falling bed of grains to get them dried. The main advantage of these dryers is the uniformity in drying and the drying time is reduced. These dryers are weather independent; require less space and energy.

In general drying air temperature depends on the type of grain, their moisture content and end use. For cereals, to be used for consumption, drying air temperature is to be limited to 70^{o}C, whereas for seed purpose it should be 45^{o}C. For oil seeds and pulses it should be 50-55^{o}C. Rapid drying develops fissures in the grain results in poor milling quality of paddy, affects, storability of wheat.

There are only few dal mills in the country where mechanical dryers are used. In general, sun drying is done for drying pulses in the process of dal milling (specially for pigeonpea the milling process takes 2-4 days longer depending on the weather.). Oil seeds are threshed/decorticated when fully dried. Conditioning is done to get maximum oil recovery. Generally dryers are not used in the oil industry.

4.9 GRAIN MILLING AND OIL SEED CRUSHING

Milling of cereals and pulses is a series of processing treatments prior to its conversion into edible form. These treatments vary from grain to grains. Flow chart for milling of paddy, pulses and oil seed given in Figures 4.3, 4.6 and 4.7.

4.9.1 Rice (Paddy) Milling

Paddy raw or parboiled is cleaned to remove all the impurities. Cleaned paddy fed in a sheller / dehusker. Traditional dehusker is an Engleberg rice huller. A huller is small mill operated by motor with a capacity 500-750 kg/h. The mill consists a cast iron roller, where shelling and polishing is done simultaneously. Therefore, bran, brokens are mixed with the husk, which is difficult to separate. As the moving part is cast iron roller, it results higher broken pieces during milling. Though, the machine is simple in operation, low in cost but results poor milling yield (total yield 62-64%, Head rice 40-50%).

The other low capacity paddy milling machines are centrifugal sheller and under runner disc sheller. A mini modern rice mill (Fig. 4.4) consists of feed hopper, rubber roll sheller, husk aspirator and a polisher in a single composit unit. The modern paddy sheller is rubber roll sheller. In it two rubber rolls are rotating in opposite directions at different speeds. Difference in surface speeds of rollers develops shearing action and results in removal of husk. Using rubber rollers only husking is done, in the machine. A blower sucks the husk and paddy-rice mixture is fed on a separator. In general, there are two types of paddy separator namely compartment type or deck type separators are used in the rice mills. Both the separators work on the principle of gravity separation. The heavier material rice remains in touch with the surface and moves along with the separator surface and carried against the gravity to upper side and discharged. Paddy being lighter moves with the gravity down and recycle to the sheller for shelling. Paddy rice mixture is recycled back to the separator. Only rice is fed in the polisher, where due to abrasion rice are polished and upper aleurone layers are removed. These layers are rich in oil content (14-26%). Rice bran is collected through cyclone separator and rice is fed in the grader. Whole rice are separated from the brokens parts through a grader. A typical flow diagram of modern rice mill is shown in Figure 4.5.

4.9.2 Wheat Milling

Traditionally wheat is milled in an attrition mill, where or (Break rolls) grains are fed in the center, moves radially out, between two emery/stone discs. Grains are compressed and sheared. The clearance between stones/is gradually reduced and whole grain flour is obtained. As the size from whole grains is reduced to fine in one go, there is significant rise in the temperature. It affects the quality of flour.

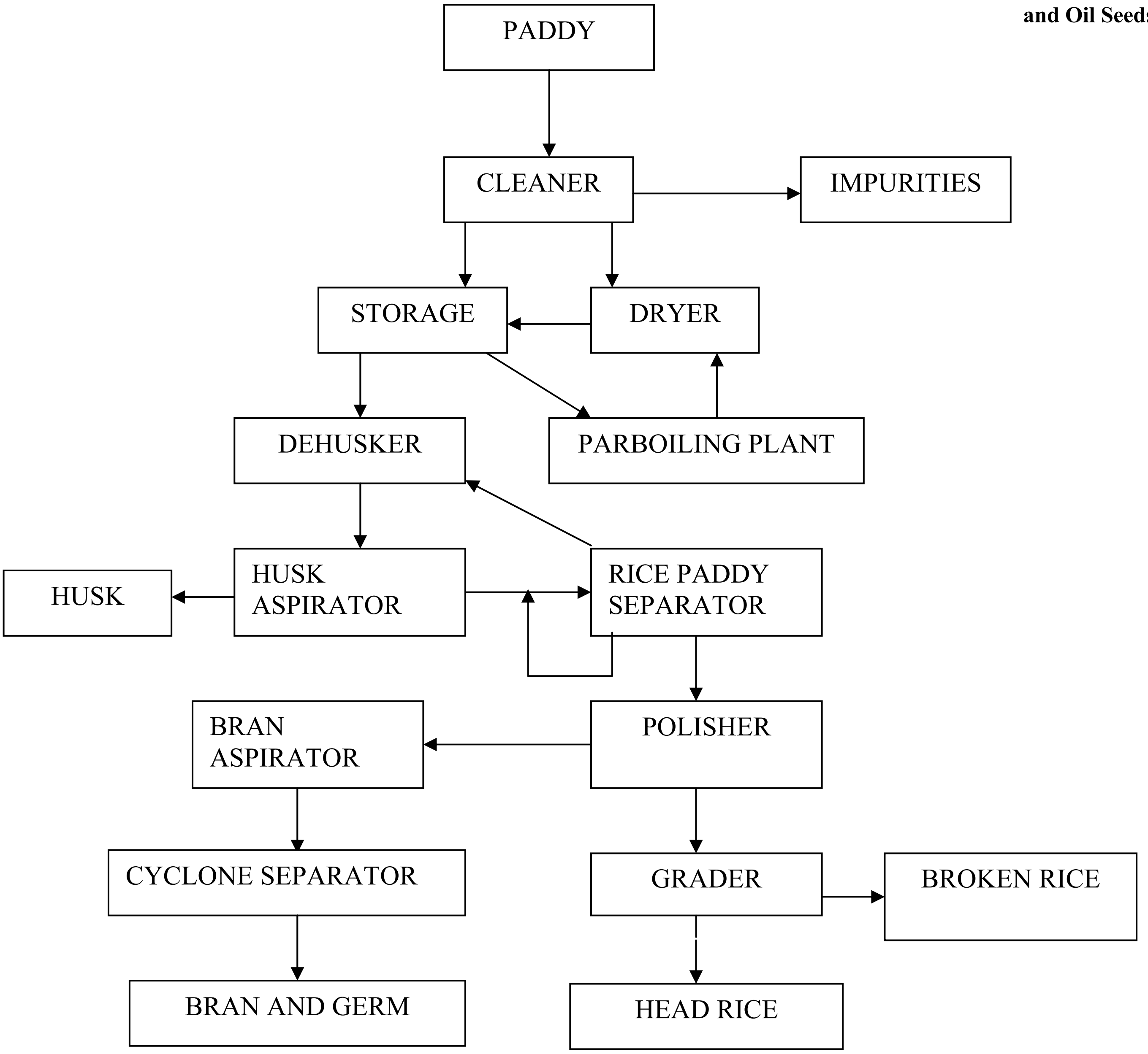

Figure 4.3: Process Flow Chart of Modern Rice Milling

Modern wheat mill consists of series of reduction rollers (about 15 to 18) where different fractions, Suji, maida etc are separated. Since size is reduced gradually, rise in temperature doesn’t take place and quality of the constitutes is better.

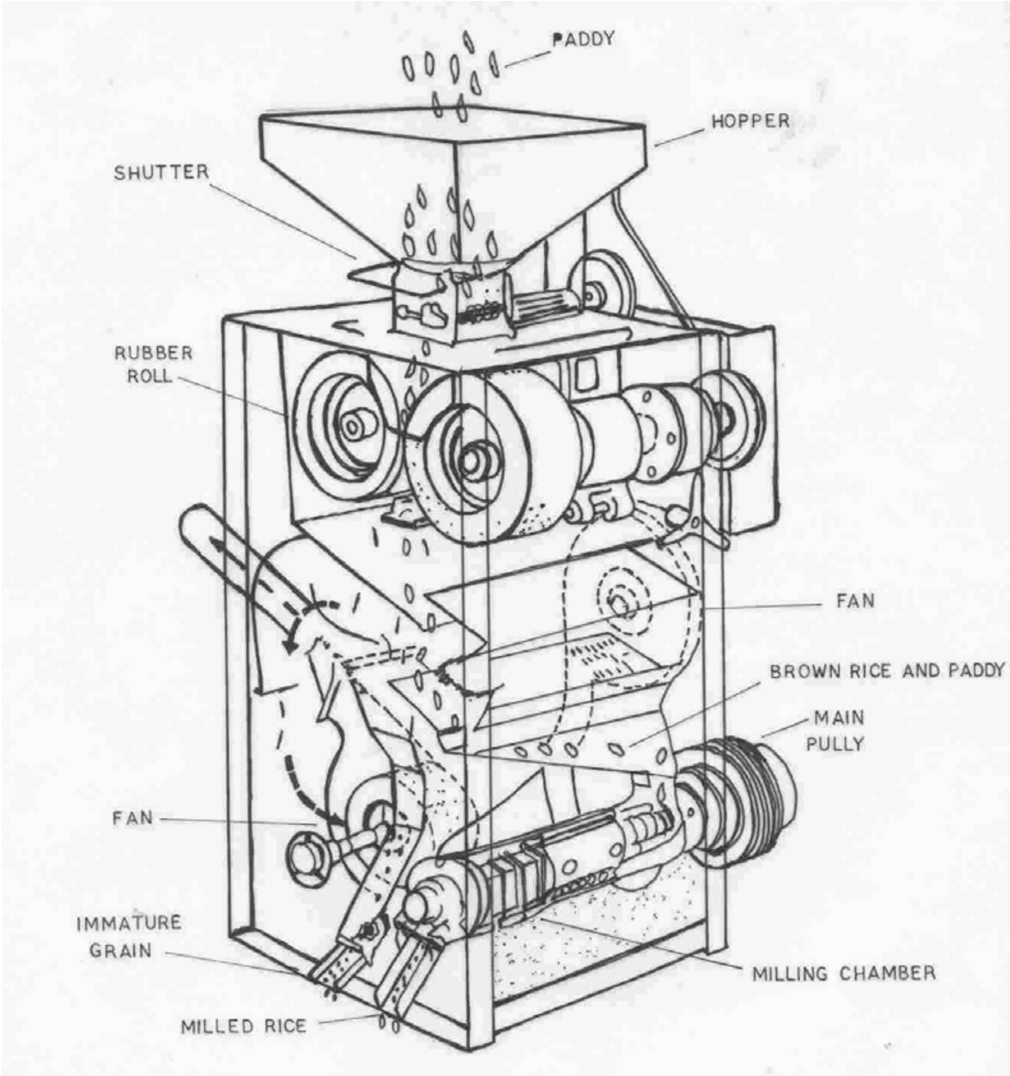

Figure 4.4: Mini modern rice (paddy) mill

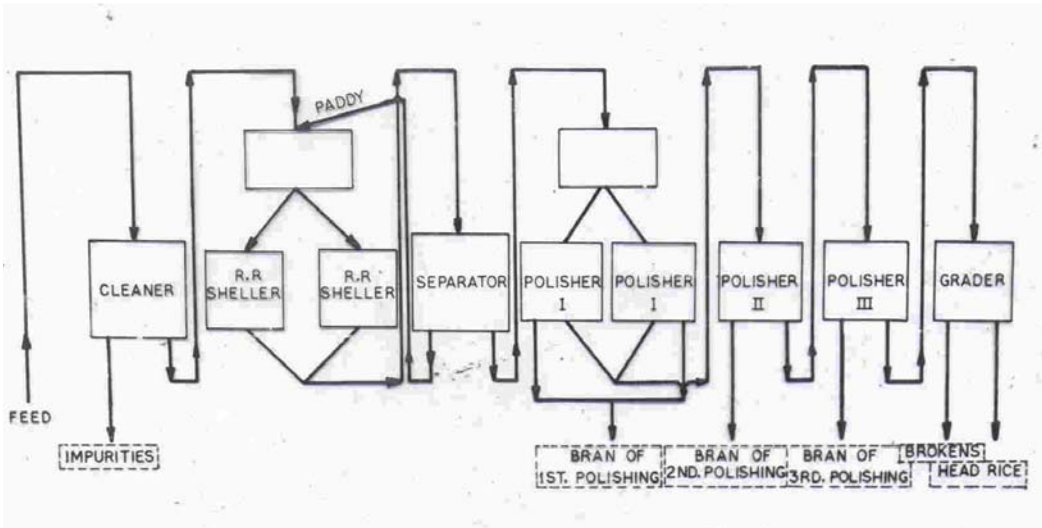

Figure 4.5: Typical Flow Diagram of Modern Rice (Paddy) Mill

4.9.3 Corn Milling

Corn can be milled by dry milling or wet milling. In dry milling moisture is raised to 24-25% and germ is separated by Beall degermer. Rest grain is dried and milled. In wet milling, corn is soaked in water (50^oC) for 1-2 days. Germ is separated for oil extraction and rest is centrifuge to make starch, dextrin, sugar syrup etc. The water used for soaking is also drained and concentrated to 35-55% solids to be used for pharmaceuticals.

4.9.4 Pulse Milling

Pulses are rich source of protein. They are traditionally milled dry. Except pigeon pea, milling of pulses is easy as binding between husk and cotyledon is poor. For pigeon pea it is most difficult.

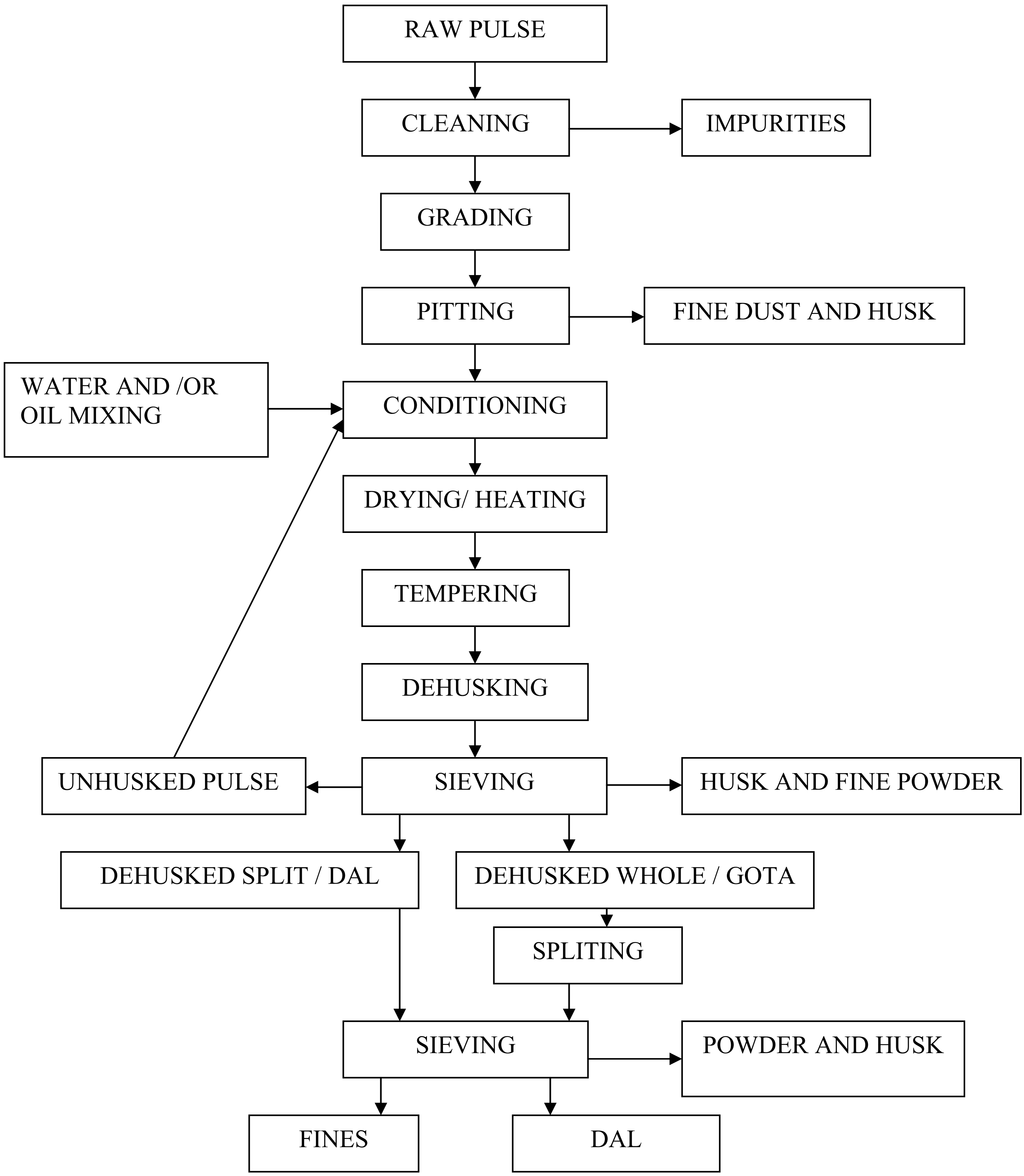

Figure 4.6: Process flow chart of improved pulse milling

Traditional milling of pigeon pea includes cleaning, scratching, treating with oil, and wetting, mixing with red earth, conditioning, scratching and splitting. In general, it yields 65-70% of dal recovery against potential of 81-84%. In modern pigeon pea milling, which includes cleaning, preconditioning, dehusking separating and splitting. It provides 72-78% dal recovery. The preconditioning includes addition of moisture, oil and drying in LSU dryer. In the modern method dal can be prepared in 1-2 days from pulses whereas in the traditional process it takes 5-10 days. A process flow chart of improved pulse milling as shown in Figure 4.6.

4.9.5 Oil Seed Crushing

Oil seeds like groundnut, castor etc are decorticated in manual or motorized decorticator. Clean seeds are crushed either in ghani operated by bullocks or mechanical power or in screw press oil expeller.

Ghanis are made of wooden taper barrel, where pestle is rotated in it. In general, 6-12 kg oil seeds are fed and hot water 1-5% is added in a batch, which takes 45 minutes to crush. A ghani recovers 60-75% of the total available oil in the oil seeds.

A screw press oil expeller is 6 to 12 bolt expeller having series of worms of different pitches. Due to pressure built up inside the horizontal casing, oil oozes out. The capacity of the expellers are to crush 60 to 120 kg oil seeds/ batch and recovers 80-85% of total available oil in two to three passes. Commercially 8 power ghanis with one mechanical oil expeller are in practice. Firstly, oil seed is crushed in ghanis and residual oil cake is passed through expeller. However, even after that 6-7% oil remains in the residual cake, which is extracted through solvent extraction process. Process flow chart of oil seed processing is given in Figure 4.7.

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Differentiate cleaning and grading.

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2. State merits and demerits of parboiling of paddy.

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3. Why conditioning of pulses and oilseeds is done during processing?

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4. "Rapid drying of grains is not recommended". Why?

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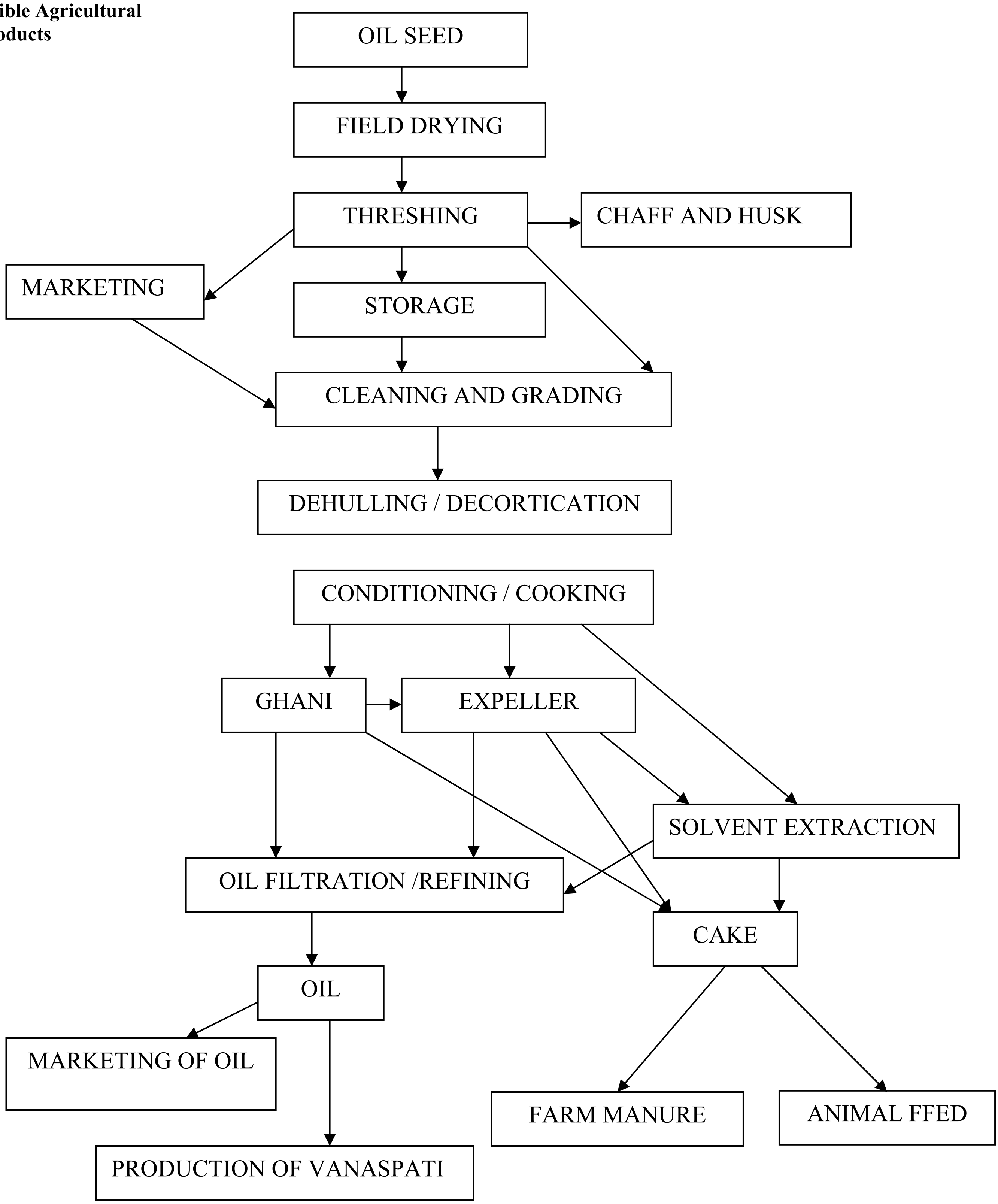

Figure 4.7: Process flow chart for oil seed processing

4.10 STORAGE OF GRAINS

Primary function of storage is to prevent food loss during the storage. The loss means any change in the availability, edibility, wholesomeness or quality of the food that prevents it from being consumed by people. Losses may be direct or indirect. A direct loss is disappearance of food by spillage, or consumption by insects, rodents, birds etc. An indirect loss is lowering of quality to the point where people refuse to eat it. All the types of losses could be conveniently categorized into two categories i.e. quantitative and qualitative.

Causes of deterioration of food grains are:

A) Environment
   i) Temperature
   ii) Ambient RH
   iii) Gaseous composition {O_2:CO_2:N_2}

B) External Micro-organisms
   iv) Insect
   v) Pest (birds, rodents)
   vi) Mites, fungi, bacteria, yeasts

C) Biochemical composition of the grain
   vii) Moisture content
   viii) Fat content

Changes occurring during storage on the grains are:

A) Wholesomeness/purity
   i) Excreta
   ii) Dockage-impurities
   iii) Damage grains

B) Quality of the grains
   iv) Weight loss
   v) Taste
   vi) Colour
   vii) Odour
   viii) Nutrition
   ix) Fat acidity
   x) Toxicity
   xi) Germination
   xii) Moisture content
   xiii) Post harvest quality: Milling and baking quality

Moisture is the most important factor, if taken care can limit development of bacteria, fungi, mites and insect attack which cause the spoilage of the grain during storage.

Some tips are:

1. Uniformly dried grains below 13% moisture content usually do not have growth of most of the microorganisms and mites.

2. Insect cannot attack the grains having moisture content below 10%.

3. In bulk storage, moisture content of the grain seldom remains uniform. Relative humidity of store, outside environment condition develops air currents. Thus within the bulk storage high and low moisture pockets develop. To check them, periodic inspection at these points is a must.

4. It is desired that relative humidity of the store should be 50-60%. Lower humidity results in over drying of the grains and develop fissures which affects milling, baking, cooking quality of the grains.

5. Higher humidity will increase the moisture content and grains are likely to be attacked by insects-pests and microorganisms.

6. Grains should be stored in dry and cool place. As the moisture content of the grains is directly proportional to the respiration of the grains.

7. The increase in respiration increases the temperature, growth of microorganisms and enzymatic activity of the bulk grain up to certain temperature.

8. Mites do not develop if the storage temperature is below 5^oC, insects do not grow if the storage temperature is below 15^oC and fungi do not develop if the storage temperature is below 0^oC.

9. Most favourable temperature for insect growth is $25\text{-}30^oC$.

An ideal storage structure should:

- have adequate protection against insect-pest.
- maintain wholesomeness and purity
- be air tight during fumigation and allow air movement during ventilation
- be easy to inspect and clean.

In India, major portion of produce is stored in a large number of small capacity rural godowns. These godowns are neither air tight nor safe from insect-pest and rodent. It is estimated that the losses in such rural godowns is as high as 30 % in humid conditions if stored for 8-10 months. The grains with scientific storage are stored in the bulk either in bag storage or in silos. The bag storage has following advantages:

✓ Small lots of a number of crops or varieties can be stored in the same space

✓ Infested bags can be easily segregated and fumigated.

✓ Each bag can be handled independently

After the green revolution our food grain production has increased many fold. However, the warehouse capacity is limited. Therefore, for short period food grains are stored in CAPS (cover and plinth storage). The maximum safe storage period for CAPS is only 6 months under ideal conditions, but in practice grain is stored in CAPS even up to 2 to 3 years. It is mainly due to poor infrastructure facility for storing food grains in bulk or godowns.

The most modern and safe method of storage of single type food grains is silo. The advantages of storing in silos are:

❖ Greater storage capacity per unit volume of space,

❖ Loading and unloading is easier and cheaper as mechanical handling devices do it.

❖ No cost of purchasing gunny bags and dunnage

❖ No danger of rodents as they are metal or RCC bins/silo

❖ Insect infestation is considerably less and if required easy to fumigate.

❖ Minimal effect of outside environment on food grains and if required easy to turn with the help of mechanical handling devices.

Check Your Progress Exercise 4

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are the causes of food grain deteriorations?

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2. List the characteristics of ideal storage structure for food grains.

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3. Compare the bag storage and silo storage methods.

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4. What is the temperature, relative humidity of the environment and moisture content requirement of the grain for safe storage.

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4.11 VALUE ADDED PRODUCTS

There is a great scope for diversification and value addition to cereals, pulses and oil seeds. Consumer preferences especially in urban areas for processed, fast foods have gained significantly. Media and television have played a significant role for domestic market. Even developed and other countries are looking towards India as a big market for processed foods. Now–a-days time is the biggest constraint with the urban people. So ready to eat, fast to cook, extruded, puffed, baked snacks are convenient have great potential in the market. Some of the possible products are listed in Table 4.5.

Besides these blended products as functional foods have domestic and export market. Functional foods are modified foods that help to improve health (provide specific health benefit) and prevent diseases when ingested. Some examples are:

- **Energy bars:** Constitute simple sugar to complex, contain about 12 % fat; 8-20 % protein and can be fortified with vitamins and minerals. It is specially made for athletic group.
- **Weight loss bars:** Balance nutrition with control calories intake and fortified with vitamins and minerals.
- **Breakfast bars:** High carbohydrate, low protein and fortified with vitamins and minerals.
- **Nutrition bars:** High protein content (15-27 g per serving) for body builders and fortified with vitamins and minerals.

Containing essential vitamins and amino acids for heart patient, diabetic patient, obey people etc.

Table 4.5: Value added products from cereals, pulses and oilseeds

Grains	Existing products	Newer products
Paddy	Raw and parboiled rice; puffed and flaked rice and rice flour	Quick cooking rice; pasta products; rice based snacks and rice bran oil
Wheat	Flour; maida; suji; dalia; and noodles	Durum wheat; puffed product and extruded products
Corn	Flour; flakes; popcorn; starch; dextrose and dextrin	Corn oil and degermed corn flour corn chips
Pulses	Dal; Powder; roasted grains; animal feed (husk)	Mixed flour; blended products; fortified products; instant dal and dal analog
Millets	Flour and puffed	Blended products and baked products
Oil seeds	Oil and cake for feed and fertilizer	Edible deoiled cake as flour; protein isolate from soy flour and blended flour

4.12 BY-PRODUCT UTILIZATION

In the present day competition an industry has to use every source of earning from the product and by-products. Moreover, unutilized by-products are an effluent to the industry. As per the environmental regulation these effluents had to be safely disposed off so that they do not pollute the environment or surroundings.

In general grains, pulses and oil seed milling units have solid by products. Some of these by-products if properly processed and used can become more profitable than the main product. A list of some by-products of cereals, pulses and oil seed milling and their possible value added products or utilization is given in Table 4.6.

Table 4.6: By-products and their utilization in the vale added products

Grain	By-product	Utilization
Paddy	Husk	Fuel: Heating value 3000-3500kcal/kg. Insulating, packaging and building material. Husk ash mixed with hydrated lime produces cement like material. Husk as an abrasive. Producing activated carbon, sodium silicate for soap industry. Pure silicon can be produced from rice husk. Silicon carbide and silicon nitride can also be produced.
Rice	Rice bran	Rice bran oil as edible oil. Defatted bran as cattle feed. Defatted bran as fertilizer. Defatted bran contains vitamins like B complex, B_1, B_6, amino acids, phosphoric acid compounds etc. for medicinal and dietetics use. Defatted bran for bakery purposes. Crude rice bran oil is used in industries, for soap, cosmetics, plasticisers, emulsifiers, protective coating, synthetic fibre etc.
Rice	Broken rice	Pasta products, rice flour, production of starch, and alcohol.
Soya bean	Defatted soya cake	Defatted soya flour for soya nuggets, soya laddu, soya granules and blended flour, soy isolates & concentrates.

4.13 LET US SUM UP

Food grains play an important role in the national economy and a day-to-day requirement of human being. Post harvest handling, storage and processing of food grains is an important operation, which can create large amount of employment at all the sectors. Moreover, it has scope to reduce the post harvest losses, which amounts to be Rs. 20,000/- crore annually. Indigenously designed food processing machines based on the properties of the grains has another employment avenue. Traditional processing technologies and machines are consuming more energy, producing poor quality turnout and results in high losses. Therefore, improved machines and technologies can solve some of these problems. However, their capacity of processing is high. There is a need to develop proper storage techniques to reduce the loss of quality and quantity of the grains during storage. Food grains can be used to produce many value added convenience products to meet special requirements. Utilization of the by-products can make food-processing industry more viable.

4.14 KEY WORDS

Sphericity : It is the ratio of the geometric mean of 3-major axis with the largest axis dimension of the grain.

Angle of repose : It is the angle between the base and slope of the cone formed, when grains are freely dropped on the horizontal plane.

Cleaning : Removal of impurities from the grains.

Grading : Separation of the grains based on their value.

Parboiling : It is hydrothermal treatment given to cereals in order to improve their milling quality.

Silo : Modern bulk storage structure where single type of grains can be stored for longer duration.

Functional foods : Modified food that help to improve health and prevent diseases when ingested.

4.15 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Industry and agriculture are two pillars of Indian economy.

2. "Whole world is looking towards India as a big market" because of large population (more than 1 billion) and unorganized food processing sector.

3. The chemical composition of the grains depend upon the crop, variety, environment in which crop is grown, type of soil, water and fertilizer applications while raising the crop.

4. The solubility of starch increases with the increase in the temperature.

5. Post harvest losses in the pulses are mainly during milling. Theoretical expected dal yield is 81-84% but actual recovery is 68-72%.

Check Your Progress Exercise 2

1. The size of the grains helps in designing the cleaner, grader and some other processing machines.

2. Winnowing and pneumatic conveying are two machines, in which terminal velocity is used for designing.

3. **The angle of repose** of the grains is the angle between the base and the slope of the cone formed, when grains are freely dropped on the horizontal plane.

4. Pycnometer is used for measuring the true density.

5. Water activity influences odour, flavour, texture, colour, enzymatic activity and microbial load of the grain.

6. For safe storage of oil seed the water activity of the store should be below 0.3.

Check Your Progress Exercise 3

1. Cleaning is to be done in the beginning of the processing, where grading is done either in between or at the end to improve the economic value, performance of processing, or storage as the case may be.

2. In parboiling the grain become harder and can withstand the milling stress. Therefore, milling improves the yield. The process of parboiling involves partly fermentation so that the parboiled rice develops off flavour and dark colour.

3. Conditioning of pulses help in loosening the husk. So milling becomes easier. Conditioning of oil seed improves oil recovery.

4. Rapid drying develops fissures on the grain. Thus during milling it breaks and its storability is poor.

Check Your Progress Exercise 4

1. The causes of food grain deteriorations are:

   (A) Environment: Temperature, Ambient RH, Gaseous composition {O_2:CO_2:N_2}

   (B) External Micro-organisms: Insect, Pest (birds, rodents), Mites, fungi, bacteria, yeasts

   (C) Biochemical composition of the grain: Moisture content, Fat content

2. Characteristics of ideal storage structures are:

   - Adequate protection against insect-pest.
   - Maintain wholesomeness and purity.
   - Sufficient air tight during fumigation and air tight during ventilation.
   - Ease in inspection and cleaning.

3. The comparison of bag storage and silo storage system:

Bag storage	Silo storage
Small lots of a number of crops or varieties can be stored in the same space	Only one commodity can be stored. However, Greater storage capacity per unit volume of space is available
Infested bags can be easily segregated and fumigated	Insect infestation is considerably less and if required easy to fumigate. No danger of rodents as they are metal or RCC bins/silo
Each bag can be handled independently	Loading and unloading is easier and cheaper as mechanical handling devices do it.

4. Ideal storage temperature below is 15^{o} C, Relative humidity 50-60% and moisture content of the grain between 10-13% for safe keeping of the grains.

4.16 SOME USEFUL BOOKS

1. Chakraverty, A. (2000) Post Harvest Technology of Cereals Pulses and Oilseeds (3rd Edition) Oxford and IBH Publication Co. Pvt. Ltd. New Delhi.

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4. Hall, D.W. (1980) Handling and Storage of Food Grains in Tropical and Sub-tropical Areas. FAO, Rome.

5. Sahay, J. (1977) Elements of Agricultural engineering (Vol. I). Agro Book Agency Patana.

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UNIT 5 FRUITS AND VEGETABLES

Structure

5.0 OBJECTIVES

After reading this unit, you should be able to:

- know production, composition, properties and factors responsible for determination of quality of fruits and vegetables and their control;
- describe post harvest handling, processing and storage of fruits and vegetables and by-product utilization of fruits and vegetables; and

- explain techno-economic feasibility of some small-scale fruits and vegetable base processing industry.

5.1 INTRODUCTION

Fruits and vegetables have an important place in our day-to-day life. Being rich in minerals and vitamins they are called protective foods. India's economy is based on the agriculture. India is one of the largest producers of fruits and vegetables in the World play a very significant role in the national economy.

India's geographical location and topography provides an excellent opportunity to produce every thing in our country. However, round the year availability of fruits and vegetables provides passive response towards commercial processing of fruits and vegetables. The people also have poor acceptability of processed foods. This often led to glut, more post harvest losses besides less contribution of processed foods in the national economy.

5.2 PRODUCTION AND IMPORTANCE

Fruits and Vegetables play an important role in agriculture, human health and national economy. In India, a decade back production of fruits and vegetables was just 50% of food grains production but it has been raised to 66% and anticipated that by 2010 it will be 80%. India is the second largest producer of fruits and vegetables in the world. India produces about 100,000 corers of rupees worth fruits and vegetables every year. However, a considerable amount of this produce in lost due to negligence and improper post harvest handling, which amounts to be 25 to 30%. Besides, this huge financial loss the wastage also affect the per capita availability of fruits and vegetables. It results in quality of health and life of majority of the people of the country.

You know, India with round the year sunshine, variate soil type, climate and topography produces variety of fruits and vegetable. Our nation is the largest producer (Table 5.1) of mango, banana, papaya, sapota, cashewnut, coconut, cauliflower, okra, capsicum, pea etc.

Though, our country is one of the highest producer of the fruits and vegetables but productivity is significantly lower in most of the fruits and vegetables as per the international bench mark (Table 1). The lower yields are mainly due to poor quality of planting material including varieties, unplanned farm management practices like fertilizer, water management and small from holding. However, some farmer have obtained better yield with competitive quality of international standard.

Table 5.1: Area, production, productivity of some fruits and vegetables

Fruits or vegetables	International benchmark (t / ha)	Area ('000 ha)	Production ('000 t)	Productivity (t / ha)	Percent world contribution (%)
Banana	35.5	491	16813	34.3	29 (I)
Mango	30.0	1487	10504	7.1	44 (I)
Papaya	-	60.5	1666.2	27.5	30 (I)
Citrus	24.5	527	4651	8.8	3
Guava	-	151	1711	11.3	- (IV)
Pineapple	60.0	76	1025	13.6	8 (III)
Sapota	-	64	800	12.4	- (I)
Coconut	-	1778	8429	4.7	18 (I)
Cashewnut	-	686	520	0.76	44 (I)
Cauliflower	-	248	4718	19.0	34 (I)
Pea	-	273	2712	9.9	38 (I)
Okra	-	349	3419	9.8	- (I)
Tomato	25.9	457	7427	16.3	9 (III)
Potato	-	1341	25000	18.6	8 (III)
Cabbage	-	258	5909	22.9	12 (II)
Brinjal	-	500	8117	16.2	38 (II)
Onion	-	493	4899	9.9	11 (II)

Source: NHB Data Book 2002

In spite of huge production, India shares only 2.3% of the world trade of fruits and vegetables. It also process only 2.5% of the total produce in a organized sector whereas Thailand 30%, Brazil 70%, Philippines 78% and Malaysia 80%. One of the reason is the varieties have poor recovery of process product for i.e. Indian tomatoes have 4 ^{o}b of total solids whereas varieties in European countries have 6 ^{o}b. Thus, to produce same quantity of tomato end product 50% more tomatoes are required in our country.

Fruits and vegetables processing industry ranks 5th in its size and employees 19% of work force which is about 1.6 million people. It accounts for 14% total industrial output against 5.5% industrial investment and contribute 18% to the GDP. Annual turnover of fruit and vegetable industry is Rs. 1800 billion and out of which Rs. 1400 billion are from unorganized sector.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Name three fruits and three vegetables in whose production our nation ranks first in the world.

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2. Give two reasons for huge post-harvest losses of perishables.

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3. List the reasons for low farm yield as compared to the international benchmark.

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5.3 TYPE OF FRUITS AND VEGETABLES

The fruit is derived from the Latin word "fructose" which means to enjoy, produce. The fruit is a product of fertilization and is a ripened ovary. Fruits are classified into pome (apple and pear); stone (mango, peach, plum, cherry), berry (strawberry, tomato); nut (walnut, cashewnut); hesperidium (citrus); synconium (fig), sorosis (mulberry); coenocarp (jack fruit) and syncarp (custard apple).

The vegetables develop from variety of plant parts (cabbage pea, potato). On the basis of plant parts used as vegetables they are grouped as fruits (gourds, brinjal, capsicum); stem (asparagus, amaranths), leaves (cabbage, lettuce, spinach) flowers (broccoli, cauliflower) and underground portion (radish, carrot, potato, onion, garlic).

For processing or storage purpose fruits are also classified as climacteric and non-climacteric fruits. The climacteric fruits are those, which develop total senescence sometime after the harvest during storage. For e.g. apple, banana, ber, fig, guava, mango, pear, peach, papaya, sapota, tomato. Whereas non-climacteric fruits ripen on the plants. for i.e. citrus, grape, litchi, pineapple, pomegranate, strawberry etc. The climacteric fruits have high rate of respiration and production of carbon dioxide and ethylene than the non-climacteric fruits during the process of ripening. It leads to change in colour, flvaour, texture and some chemical changes.

5.4 COMPOSITION AND FOOD VALUE

You know that fruits and vegetables are considered as protective foods as they are major source of nutritients such as vitamins and minerals. The quantity and quality of these nutrients vary with the variety, pre-harvest practices and maturity. These nutrients imparts their colour, flavour, and texture. Colour of the fruits is basically due to sugar derivatives of anthocynidins. Flavour in the fruits depends on the proportion of sugars and acids. Besides that there are some volatiles flavouring compounds. The texture of the fruits is governed by polysaccharides. Fruits are also containing phenolics compounds. They impart astringency, bitterness and aroma, which provide resistance to pathogens and stress.

Food value namely major constituent, vitamins and minerals of some important fruits and vegetables have been given in Table 5.2 A, B and C at their maturity stage.

5.5 PHYSIOLOGY OF FRUITS AND VEGETABLES

Physiological maturity is the state of harvest of fruits and vegetables, which provides some flexibility of time for marketing the produce, so that produce attain desirable eating quality when it reaches the consumer. The produce harvested prior to attainment of physiological maturity exhibit lack of flavour and loose moisture rapidly. If harvested late may be overripe and have very short post harvest life.

Objective and subjective methods for assessing the maturity of fruits and vegetables have been standardized. They are classified as :

- Physical methods
- Chemical methods
- Biochemical methods

Table 5.2a: Food values of fruits and vegetables

Name of produce	Major constituents (percent)					
	Moisture	Protein	Fat	Mineral matter	Fiber	Carbohydrate
Fruits						
Apple	85.9	0.9	0.1	0.3	-	13.4
Aonla	81.2	0.5	0.1	0.7	3.4	14.1
Banana	61.4	1.3	0.2	0.7	-	36.4
Guava	76.1	1.5	0.2	0.8	6.9	14.5
Lime	84.6	1.5	1.0	0.7	1.3	10.9
Mango	86.1	0.6	0.1	0.3	1.1	11.8
Orange	87.6	0.9	0.3	0.4	-	10.6

Papaya	89.6	0.5	0.1	0.4	-	9.5
Pear	86.9	0.2	0.1	0.3	1.0	11.5
Pineapple	86.5	0.6	0.1	0.5	0.3	12.0
Tomato	94.5	1.0	0.1	0.5	-	3.9
Leafy vegetables						
Cabbage	90.2	1.8	0.1	0.6	1.0	6.3
Drum stick	75.0	6.7	1.7	2.3	0.9	13.4
Radish leaf	87.4	2.2	0.5	2.6	2.2	5.1
Spinach	91.7	1.9	0.9	1.5	-	4.0
Roots and Tubers						
Carrot	86.0	0.9	0.2	1.1	1.2	10.7
Onion	86.8	1.2	0.1	0.4	-	11.6
Potato	74.7	1.6	0.1	0.6	-	22.9
Radish	94.4	0.7	0.1	0.6	-	4.2
Sweet Potato	68.5	0.7	0.2	1.0	-	38.7
Yam	78.7	1.2	0.1	0.8	0.8	18.4
Other Vegetable						
Brinjal	91.5	1.3	0.3	0.5	-	6.4
Ash gourd	96.0	0.4	0.1	0.3	-	3.2
Cauliflower	89.4	3.5	0.4	1.4	-	5.3
French been	91.4	1.7	0.1	0.5	1.8	4.5
Cucumber	96.4	0.4	0.1	0.3	-	2.8
Lady Finger	88.0	2.2	0.2	0.7	1.2	7.7
Pea	72.1	7.2	0.1	0.8	-	19.8
Pumpkin	92.6	1.4	0.1	0.6	-	5.3
Snake gourd	94.1	0.5	0.3	0.7	-	4.4

Source: NIN, ICMR, Hyderabad, 1999

Table 5.2b: Food values of fruits and vegetables

Name of Produce	Minerals, (mg /100 g)								
	Cal-cium	Phos-phorus	Iron	Magne-sium	Sod-ium	Pota-ssium	Copper	Sul-phur	Chlo-rine
Fruits									
Apple	10	20	1700	7	28	75	0.13	7	1
Aonla	50	20	1200	-	5	225	0.18	-	-
Banana	10	50	400	34	36.6	88	0.40	7	8
Guava	10	40	1000	8	5.5	91	0.34	14	4

Lime	90	20	300	-	-	270	0.16	-	-
Mango	10	20	300	27	26	205	0.20	17	3
Orange	50	20	100	9	4.5	93	0.58	7	5
Papaya	10	10	400	11	6	69	0.20	13	11
Pear	10	10	700	-	-	-	-	-	-
Pine-apple	20	10	900	20	34.7	37	0.36	20	13
Tomato	10	20	100	12	12.9	146	0.14	11	6
Leafy Vegetables									
Cabbage	30	50	800						
Drum stick	44	70	7000						
Radish leaf	12	90	4800						
Spinach	60	90	5000						
Roots and Tuber									
Carrot	80	40	1500						
Onion	180	30	700						
Potato	10	50	700						
Radish	50	30	400						
Sweet Potato	30	40	900						
Yam	50	20	600						
Other Vegetable									
Brinjal	20	60	1300						
Ash gourd	30	20	500						
Cauli-flower	30	60	1300						
French been	50	30	1700						
Cucu-mber	10	30	1500						
Lady Finger	90	80	1500						
Pea	20	80	1500						
Pumpkin	10	30	700						
Snake gourd	50	20	1300						

Source: NIN, ICMR, Hyderabad, 1999

Table 5.2c: Food values of fruits and vegetables

			Vitamin			
Name of Fruit/ Vegetable	**Calorific value (cal/100g)**	**Vitamin A (IU/100g)**	**Vitamin B (mg/100g)**	**Vitamin C (mg/100g)**	**Nicotinic acid (mg/100g)**	**Riboflavin (mg/100g)**
Fruits						
Apple	56	-	0.03	2	0.2	0.03
Aonla	59	-	0.03	700	0.2	0.03
Banana	153	-	0.04	19	0.3	0.03
Guava	66	-	0.03	300	0.2	0.03
Lime	59	26	0.02	63	0.1	0.02
Mango	50	4800	0.04	24	0.3	0.05
Orange	49	350	0.05	68	0.3	0.06
Papaya	40	2020	0.04	46	0.2	0.05
Pear	47	14	0.02	-	0.2	0.03
Pineapple	50	60	0.03	63	0.2	0.04
Tomato	21	320	0.04	32	0.4	0.05
Leafy Vegetables						
Cabbage	33	2000	0.06	124	0.4	0.12
Drum stick	96	11300	0.06	220	0.8	0.12
Radish leaf	33	6700	0.05	65	0.5	0.12
Spinach	32	5500	0.05	48	0.5	0.11
Roots and Tubers						
Carrot	47	2000-4300	0.04	3	0.4	0.02
Onion	51	-	0.08	11	0.4	0.01
Potato	99	40	0.10	17	1.2	0.01
Radish	21	-	0.06	15	0.4	0.02
Sweet Potato	159	-	0.05	-	0.3	0.01
Yam	79	434	0.06	-	0.7	0.08
Other Vegetables						
Brinjal	34	5	0.05	23	0.8	0.06
Ash gourd	15	-	0.06	5	0.4	0.01
Cauliflower	39	38	0.10	66	0.9	0.08
French been	26	221	0.08	14	0.3	0.06
Cucumber	14	-	0.03	7	0.2	0.02
Lady Finger	41	58	0.06	16	0.6	0.06
Pea	109	139	0.25	9	0.8	0.01
Pumpkin	28	84	0.06	2	0.5	0.04
Snake gourd	22	160	0.04	-	0.3	0.04

Source: NIN, ICMR, Hyderabad, 1999

5.5.1 Physical Methods

In the physical method, the maturity of the fruit is judged by visual observations or by simple methods. They are size, shape, colour, weight, specific gravity, firmness, juice content, total soluble solids (TSS), and produce holding strength by the pedicle of the plant.

Usually size and weight of individual fruit depends on several factors so they can be considered only when such factors are known. For ex. Cultivar, planting material, nutritive available, soil type and climatic condition effect the size and weight of individual fruit. Some fruits develop colour, angularity and their specific gravity changes with the maturity. In general fruit and vegetable when they attain maturity do not develop enough force required to detach them from plant. Table 5.3 provides some indices of maturity of fruits and vegetables.

Colour charts are used for determing the maturity of some fruits, which changes the colour on maturity like stone fruits, tomatoes and banana. Colour charts or photographs can be provided to the worker engaged in harvesting to make the process effective.

Firmness is measured as degree of softness of the fruit and measured by the penetrometer. After choosing an appropriate plunger, hold the fruit against firm surface. Press the plunger with the uniform speed till it punctures the fruit peel.

In some fruits like grapes, citrus, mango, muskmelon etc sugar is the main soluble solids in the fruit juices. Thus, total soluble solids (TSS) measured by the hand refractrometer can considered as index for degree of maturity of these fruits. In juicy fruits like citrus, juice content can be an index of maturity.

5.5.2 Chemical Methods

The fruit maturity is judged by the chemical analysis of the constituents. They are titrable acidity, TSS/acid ratio, sugar/acid ratio, starch content, tannin content etc. In many fruits acidity decreases with the maturity. It can be determine by titrating fruit juice with 0.1 normal sodium hydroxide and phenolphthalein as an indicator.

Some fruits acidity alone cannot be taken as index of fruit maturity. However, a ratio of TSS to acid provides better judgment. We have already read that TSS can be measured by hand refractrometer.

Sugar either free or as derivative play an important role in imparting taste, flavour and texture to the fruits. It is considered as reliable index of maturity of fruits. As the fruit ripens, its starch is partly converted into sugar. Thus, measurement of starch by colorimetric method or by iodine reaction method can also provide an index of maturity.

Table 5.3: Maturity indices for fruits and vegetables

Fruits/Vegetable	Maturity Indices/Characteristics
Mango	Specific gravity 1.01-1.02, fullness of checks and roundness of shoulders
Banana	Angularity to round shape change of colour in some cultivars

Citrus	TSS:acid =12
Grapes	TSS: acid=20
Apple	TSS 12; Firmness 7kg
Peaches/Pears	Colour change from green to yellow, TSS=12
Plums/ber	Skin colour change
Custard apple	Turning of skin as creamy white between segments
Pomegranate	TSS = 16
Brinjal	Glossy skin and seeds are not hardened
Cabbage	Solid
Carrot	Size
Brocoli/cauliflower	Compact flower
Cucumber/Gourd	Tender, before hardening of seed coat
Lady finger	Non-fibrous, tips of pods pliable
Onion	40-50% tops fall
Peas	Shining green, filled
Capsicum	Green and shining
Chilli (hot)	Dark red colour
Potato	Foliage get dried
Tomato	For processing : Red For medium distance market : turning stage (pink) For distant market : breaker stage (green ripe)

Source: Research compilation from different papers and reports of PHTS (Post Harvest Technology Subject)

5.5.3 Biochemical Methods

Evolution rates of carbon dioxide and ethylene are considered as the most reliable methods to judge the maturity index of the fruits. In the climacteric fruits, carbon dioxide evolution increased during ripening stage. Ethylene is considered as ripening hormone and is also a good indicator for judging maturity, suitability of storage and other end uses. However, for non-climacteric fruits their suitability has not been established.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Why fruits and vegetables are called protective foods?

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2. Name the instrument used to measure the firmness of fruits and vegetables.

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3. Name the instrument used to measure total soluble solids of fruit juices.

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5.6 CULTURAL PRACTICES

Soil type and climate do affect the quality of the end produce. But these are not in the hands of the growers. The cultural practices like soil-water management, canopy management, fruit thinning, doze and time of mineral application chemical sprays, pest management, affect the quality and quantity of horticultural produce not only at the time of harvest but also during storage. It is difficult to analyze the effect of each one of them individually. Affect of cultural practices on citrus fruit is shown in Table 5.4.

Table 5.4: Cultural practices affecting the quality of citrus fruit

Cultural Practices	Size	Weight	Maturity	Rind thickness	Soluble solids	Acidity	Juice content	Ascorbic acid	Colour yellow
Excess irrigation	+	+	+	-	-	-	+		
Girdling	+	+			+	-	+		
Mineral Nutrition									
Nitrogen	-	-	-	+	+	+	-	-	-
Phosphorus	-			-	-	-	-	+	-
Potash	+	+	-	+	-	+	-	+	-
Magnesium	+	+			+	-	+	+	
Zinc	+				+		-	+	
Chemical Sprays									
Oil emulsion					-				-
Lead arsenate	-		+	+	+	-		+	
2,4-D	+	+	-	-	-	+			-
GA	-	-	+	+	-	+	-	+	

Source: Research compilation from different papers and reports of PHT (Post Harvest Technology Subject)

Blank space shows no information available

+ : indicates positive effect; increase, hasten, thick, hard, smooth or good flvaour

- : indicates negative effect; decreases, delays, thin, soft, rough and poor flavour

5.7 PRE-HARVEST TREATMENTS

It is well known that mineral content greatly affect the fruit quality at harvest and changes after harvest. Post harvest shelf-life is mainly dependent upon level of calcium in the fruit. Usually application of higher level of nitrogen, phosphorous and magnesium and lower level of potash and boron leads to calcium deficiency in fruits and reduces the post harvest shelf-life. Pre-harvest treatments of calcium delays ripening and senescence and improves the quality of produce. Low calcium content in tissues lead to physiological disorders such as : (i) bitter pit in apples ; (ii) cork spot in pears; (iii) end rot in tomatoes ; (iv) tip burn in lettuce and (v) hollow heart in potatoes.

Application of zinc and boron improves the mobility of calcium in the leaves and to the fruit. It increases firmness, soluble solids, organic acids, and ascorbic acid and reduces disorders. Chemicals used to extend the shelf life of fruits and vegetables are listed in Table 5.5.

Table 5.5: Chemicals and their schedule of pre-harvest application to enhance

Post Harvest Shelf-life of Horticultural Produce

Fruit/ Vegetable	Chemical & concentration	Time of application (Days before harvest)	Response
1. Apple	Boric acid (0.1-0.2%) silver-nitrate, 75 ppm	60 and 45 45	Improve calcium mobility Enhance shelflife
2. Mango	Calcium nitrate (1%) Or Calcium chloride (0.6%) Bavistin 0.1%		Enhances shelf-life Controls anthracnose and Stem end rot
3. Mango	Thiaphenate methyl 0.05% Gibberllic acid 10-15 ppm Phosphonomethylcin 5%	10	Post harvest losses Delayed ripening High TSS
4. Guava	Calcium 0.6%	20 and 10	Delayed ripening
5. Ber	Calcium compound 1.79/litre Ethereal, 750 ppm	10	Delayed fruit ripening Hasten maturity
6. Grape	Calcium nitrate 0.75%	10	Reduces weight loss & decay
7. Onion	Meleic hydrazide 2000-3000 ppm	15	Reduces sprouting during storage and reduces losses

Source: Research compilation from different papers and reports of PHTS (Post Harvest Technology Subject)

5.8 SAFE HARVESTING

Harvesting is an important unit operation in horticultural crop production. Though, it appears simple but it does require certain skills. Harvesting period is usually short. Improper harvesting may result in poor quality produce and also damage the plant. Therefore, the harvesting is further subdivided in following sections:

- Identification
- Clipping / Cutting / Picking
- Collection
- Do's and don'ts of Quality Harvest

5.8.1 Identification

Identification of properly mature fruits based on the parameters studied earlier i.e. size, shape, colour, acidity, TSS, firmness etc is the first most important task of the person engaged in harvesting.

5.8.2 Clipping / Cutting / Picking

Identified fruit which is separated from the plant is called clipping/cutting/picking. Improper harvest not only damages the produce but also causes injury to the plant. Manual method of harvesting includes holding the fruit, twisting it and pulling it. It damages the fruit as thumb impression and due to the pressure some times it injures the fruit near the pedicle and also plant stem. On such fruits mould growth is observed after 48-72 h. So they are not suitable for long distance transport.

Clippers and knives provide smooth cut with the desired length of pedicle. Long pedicle is likely to damage neighbouring fruits during transport. It is preferred to have as small a pedicle as possible. Some times fruits are not accessible. Pricking poles attached with collecting bags can be used without climbing on the tree. Tripod ladders could also be used, which are stable and person can reach the fruits.

5.8.3 Collection

In general harvested fruits are dumped on the ground. Where these fruits come in contact with soil. Impact by which it is dropped on the ground and microbes present in the soil contaminates the fruits. Therefore, harvested fruits are to be collected in cloth bags, put on shoulder. These bags are to be carefully unloaded in the plastic crates kept under shade. Plastic crates may be expensive in the beginning but they are reusable. They help in reducing post harvest damage during transport and provide sufficient ventilation to remove field heat. They can also be stacked easily.

5.8.4 Do's and Don'ts of Quality Harvest

i) Harvest as per the market need and proper maturity stage of produce.

ii) Use proper tool to harvest, bag-to collect and crate during handling.

iii) Containers used should be clean, smooth, free from rough edges.

iv) Avoid hand touching of the fruits.

v) Train pickers for harvesting, handling the produce.

vi) Keep produce free from soil contamination.

vii) Keep produce in shade.

viii) Harvest early morning or late evening as these are low temperature at that time.

ix) Field sorting and packing is to be promoted.

x) Cure the roots and tubers before storing.

5.9 POST HARVEST TREATMENTS

On-farm post harvest treatments are basically into two:

1. Removal of field heat by cooling
2. Disinfections of the produce

5.9.1 Pre-cooling

Cooling of fresh produce means removal of the field heat. You remember that in article 2.8.4 it was mentioned "harvesting/picking should be done in the early morning or late evening during low temperature". It is well proven that if the fresh produce temperature is lowered by $10^{o}C$ in first hour, its shelf life is doubled. You know fruits and vegetables are living. They respire if the temperature is more, their respiration rate increases. Thus, during handling it releases more heat and deteriorates the quality of the produce. The fresh produce can be cooled by:

- Natural cooling
- Forced air cooling
- Hydro cooling

Natural Cooling

The natural cooling is the simplest method in which harvested produce is to be kept in shade on a pucca floor or polyethylene sheet. It is the slowest method of cooling and sometimes time taken to remove the field heat is so high that spoilage of produce starts during cooling itself. Some people misunderstood this and kept the freshly harvested produce in cold room. It may cause harm to the produce as warm fresh produce releases water which when condenses and spoils the produce. Thus, such places should be equipped with good ventilation to remove the field heat.

Forced Air Cooling

Cold air is blown above the freshly harvested produce. It is many times faster than the natural cooling. It suits most of the fruits, which cannot be dipped inside the water for hydrocooling for i.e. strawberry, grapes etc. The main advantage of forced air cooling is that it not only carried heat librated but also carries the moisture evaporated from the fruits. The only disadvantage is if excess air is blown. Then loss of weight of fruit is high.

Hydro Cooling

It is the most effective method in which freshly harvested produced are dipped in cold water or cold water is sprayed over them. The advantage of this method is that it is fastest method of cooling and washing the produce. However, it requires more energy because surface water of the fruit is to be removed before packaging is done by forced aeration. The temperature of water should not cause cold injury or the shower pressure shouldn't damage the produce.

5.9.2 Disinfections of Produce

Fruit and Vegetables are exposed to nature, which is a vast ocean of microbial load. As long as they are on the plants, there resistance power is more. Once detached, the produce needs to be disinfected. The produce can be disinfected by treating with the hot water or chemicals (fungicides).

Hot Water Treatment

Most of the microorganisms and heat sensitive. Thus by dipping the produce for 1 to 5 minutes (depending on type of produce) in hot water (50-55^{o}C) checks the microbial load. In some of the produce time-temperature combination for disinfection is carried out this is given in Table 5.6. After the hot water treatment produce is kept in a cool room and gentle air is to be blown. It removes surface moisture and cools the produce.

The heat treatment temperature and time depends on the type of fruit/vegetables, and their microbial load. Care should be taken that it should not affect the quality of fruit.

Chemical and Fungicidal Treatments

Dipping in aqueous solution of some chemicals reduces the physiological loss in weight and microbial load and enhances the shelf-life of the fruit and provides uniform ripening. Some chemical treatments are given in Table 5.7.

Table 5.6: Hot water treatment to horticultural produce

Fruits/ Vegetables	Temperature (°C)	Time controls (sec/min)
Mango	52 °C 5 min	Controls anthracnose
Mango	46°C 65 min	Anthracnose and fruits fly
Citrus	50 °C 2 min	Enhances post harvest shelf-life
Capsicum	55 °C 12 ± 2 sec	Checks respiration, PLW and shriveling during storage. Enhances Post harvest shelf-life and capacity to with stand thermal stress.

Source: Research compilation from different papers and reports of PHT (Post Harvest Technology Subject)

Table 5.7: Post harvest applications of chemicals / fungicide

Fruit	Chemical / fungicide and doze	Treatment	Effect
Mango CV. Banganapally	Wax, 6%	1 min	Reduces PLW
Mango	Ethylene 10-100 ppm Ethepon/ Etheral 500 ppm	21-25°C for 12-48 h hot water	Uniform ripening and colour development
Mango	Calcium chloride solution less than 4%	Dipping	Delayed ripening
Banana	Waxol –12 Potassium permanganate	Dipping	Delayed ripening
Banana	Sulphur 0.1%	Pasting	Control crown fungi
Grape	Sulphur oxide fumes or 0.5% water spray	Fumigation	Reduces respiration, enhances shelf-life and control growth and spread of rot
Citrus	Waxing bavistin or GA_3-200 ppm or Cytokine 20 ppm	Dipping/spraying	Control spoilage, enhances shelf-life
Guava	GA 200 ppm	Sealed PLDE bags	Enhances shelf-life
Peaches	Potassium permanganate 1000 ppm	Paper soaked lined CFB	Enhances shelf-life
Apples	Calcium chloride 2-3%	Dipping	Helps in ripening
Cabbage	Alum 15% or lime powder at butt end	Treating	Controls Bacterial soft rot

Source: Research compilation from different papers and reports of PHT (Post Harvest Technology Subject)

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Name the physiological disorder occur in the potato and apples and its cause.

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2. List the steps of safe harvesting of horticultural produce.

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3. Why pre-cooling is essential in the fruits and vegetables?

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5.10 POST HARVEST MANAGEMENT

In our country the most (above 97%) of the horticultural produce is consumed as fresh. The post harvest handling involves movement of the horti produce from field to the dining table. This may be in bulk or retail. The better quality, produce fetches better returns. Therefore, the quality of produce is to be maintained by keeping a close eye on the movement of the produce. The steps involves are:

- Sorting
- Cleaning

- Trimming/chopping
- Waxing
- Grading
- Packaging
- Labelling
- Storage
- Transportation

5.10.1 Sorting

It is an important unit operation, which is advised to be carryout at the field itself. Removal of damaged, diseased, immature or over mature produce are to be rejected in the field. By removing them, the cost incurred in their transportation and handling can be saved. Moreover, these produce have higher respiration rate, so heat evolved by them is higher and very likely spoil the adjoining produce.

5.10.2 Cleaning

Fruits and Vegetables are exposed to the outer atmosphere. Thus, soil, dust and other impurities are adhered to their peel. Cleaning may be dry or wet (washing) is required to remove the adhered impurities from the produce. It helps in improving the appearance and also cools the produce. Some fruits, whose peel is very soft do not require washing with water like strawberry, kiwifruit, avocados etc. For them gentle air is blown to clean them. Fruits whose natural wax is removed during washing is also not washed with the water.

Spray washing or dipping in a tank with gentle brushing is done to remove adhered impurities. The choice of brushing mainly depends upon type of commodity and contamination.

Hygienic and sanitary conditions are to be maintained to check the spreading of disease and microbial load of washing water. Water may be treated with chlorine (100-150 ppm) to control spores.

5.10.3 Trimming

Some crops contain non-edible parts/excess leaves with the produce. These unwanted portion not only creat an unnecessary bulk but also lead to microbial infection and water loss. Thus such produce are to be trimmed/detopped before storage and handling.

5.10.4 Waxing

Food grade waxing of green vegetable like cucumber, tomatoes and fruits like citrus, apples, peaches is a common practice. It helps in reduction in loss of water during handling and marketing and enhances the shelf-life. Wax coating is done by mist applicator on a moving belt. After wax coating the produce their surface has to be dried before further handling.

5.10.5 Grading

Grading of the produce based on size or colour often fetches premium price in the market. Uniformly graded material provide better appearance and they are easy to pack. Experienced person generally does the grading in India manually.

However, for round produce, size base grades and for some specific fruits weight base mechanical graders are available in different capacity.

5.10.6 Packaging

The main purpose of packaging is to protect the produce during handling, transportation and storage from deterioration due physical, chemical or biological factors. Horticultural produce are highly perishables. After grading, the produce have the uniform maturity and requirement for safely against mechanical injury, and physiological activities like respiration. The package should have the following features:

- ✓ It should have sufficient mechanical strength which can withstand dead load during transportation (including impact and vibrations).
- ✓ It should be well aerated to remove respiration heat and humidity.
- ✓ It should be attractive and economical.

In general horticultural produce are handled through wooden cartons, corrugated fiberboard boxes and plastic crates. To avoid damage produce by touching each other liners/fillers are used of corrugated fiberboard or newspapers or grasses. Polyethylene lines are used to increase the humidity and decrease the water loss from the fruits.

5.10.7 Labelling

Fruits and Vegetables are delicate. Labelling of packages helps the people handling them during loading/unloading, stacking during storage or transportation. The label should contain information regarding maximum stack height, storage temperature and relative humidity conditions, date of packing and best before use. It should also have name of the commodity, its net weight and address of the producer.

5.10.8 Storage

In general fruits and vegetables are stored at low temperature and high humidity. It helps in reduction in respiratory rate and enhances the shelf-life. Appropriate storage conditions for storage of different horticultural produce is given in Table 5.8.

For temporary/transit storage for 1-day produce can be kept in the evaporating cool chamber where humidity is 90-95% and temperature is 10-15 ^{o}C lower than the atmospheric temperature.

Horticultural produce can be stored in modified atmosphere package (MAP) or controlled atmosphere (CA). In this storage, the oxygen concentration is reduced (in general below 5%) and carbon dioxide concentration is increased (3 to 7%). It helps in enhancing the shelf life and maintaining the quality for longer period.

Table 5.8: Storage conditions for fruits and vegetables

Produce	Temperature (^oC)	Relative Humidity (%)	Storage life
Fruits			
Apples	1-2	90-95	12 months
Grapes	1-2	90-95	1 month
Citrus	3-8	80-90	3 month
Peaches	1-5	80-90	2 weeks
Pears	1-5	90-95	4-6 weeks
Strawberry	2-5	95 +	1 week
Banana	12-15	80-85	2 week
Mango	10-15	85-90	3 week
Vegetables			
Cabbage	0-2	95-98	3-6 months
Cauliflower	0-2	90-95	4-6 weeks
Cucumber	10-13	95	2 weeks
Brinjal	10-12	90-95	1 week
Onion / garlic	0 to 5 or 25-28	65-70	6 months
Ginger	10-13	65	6 months
Okra	7-10	90-95	10 days
Pea (Green)	0	95 +	2 weeks
Potatoes	4-8	90-95	10 months
Tomatoes	12-15	90-95	1-2 weeks

Source: Food Preservations by modified atmosphere, By Calderon amnd Golan, CRC Press

5.10.9 Transportation

The refrigerated vans are the best method for transporting the produce from one place to another. However, it is not common practice in our country. Therefore, open vans with system of air movement to remove the respiratory heat should be practiced. In the van stacks should be arranged uniformly with thick cushioning pads (straw) to absorb the shocks.

5.11 PROCESSING OF FRUITS AND VEGETABLES

Fresh fruits and vegetables contain 70% or above water on wet basis. Large amount of water and respiration trigger the chain reactions of microbial activity. The purpose of processing is to develop value added products which are stable. The stability can be obtained by:

- Reducing the chemical potential of water by
  - application of heat
    - Pasteurization
    - Canning
    - Dehydration (Drying & reducing a_w)
    - Concentration
  - addition of solute
    - Jams, jellies, marmalades
    - Salting
- Fermentation
  - Pickling
  - Beverages (Fermented & non fermented)

5.11.1 Reducing the Chemical Potential of Water

Water present in the fresh produce can be removed by dehydration or addition of solutes which can strongly bind the water and not allow it to take part in deteriorating reactions.

a) Dehydration

It is the simplest and the oldest method to remove the free water from the produce and make it shelf stable. The quality of dehydrated materials depends upon the method of drying, temperature and rate of drying. Natural sun drying is the oldest practice but it provides uneven drying, sometimes gets contaminates from the atmosphere. Therefore, indirect sun drying (solar dryer), or the dryers operated with electricity, diesel or gas can be used to develop good dehydrated product.

Prior to drying, the product is to be blanched and exposed to sulphur fumes which helps in drying and maintaining the colour and flavour of the dried product Table 9 provides the temperature required for drying different produce. Excess temperature may cause loss of nutrients and or caramalization of sugar. Dried product can be stored for few months without refrigeration.

Table 9: Drying air temperature and time required for drying for different produce

Produce	Drying air temperature (^oC)	Time required for drying (h)
Apple	50-55	6-8
Banana	50-55	6-8
Grapes	50-55	24-48
Mango (unripe)	50-55	24-36
Garlic	55-60	6-8
Onion (slices)	50-55	8-12
Pea	55-60	12-18
Green chilli (cut)	55-60	4-5
Spinach	55-60	4-5
Cauliflower	55-60	8
Potato chips	50-55	4.

b) Solute Addition

It is well known that by adding sugar or salt, fruits and vegetables can be preserved longer. These chemicals bind the water present in the food and thereby prevent the water to take part in deteriorating reactions. Jams, Jelly, fruit bar, preserves are sugar-preserved products whereas pickles are salt preserved.

The products can be made of intermediate moisture content (18-35%) by partially drying them in air. Such products retain more nutrients, colour, flavour and require less energy in product development.

5.11.2 Fermentation

It is an aerobic/partial anaerobic oxidation process. During the process desirable microorganisms are produced. Some of the useful products from fermentations are acids and alcohols.

The list of some products prepared from fruits and vegetables are given in Table 10.

Table 10: List of some products prepared from fruits and vegetables

Produce	Existing Products	Newer Products
Green Mango	Pickle, chutney, dried slices powder	Drink, juice, concentrate
Ripe Mango	Canned slices, pulp, juices nectar, jam, bar	Frozen slices, concentrate wine, vinegar
Banana (unripe)	Chips	Defatted chips and powder
Banana ripe	Pulp, figs	Powder, bar
Grapes	Raisins, juice, wine	Concentrate
Guava	Jelly, juice, nectar	Bar, powder
Apple	Juice, jam	Juice concentrate, bar dehydrated slices
Oranges	Juice	Juice concentrate, segments
Papaya (raw)	Tuttifruity	Papain
Papaya (ripe)	-	Pulp, slices
Aonla	Preserve, pickles, juices power	Salted and sweet segments
Pea	Dehydrated, brive solution canned	-
Carrot	Juice, pickle, canned	Dehydrated
Onion	Dehydrated slices powder	-
Tomato	Puree, sauce, drink	Powder
Chilli	Dehydrated, powder, pickle	Paste

5.12 BY PRODUCT UTILIZATION

Fruits and Vegetable processing industry is called as sunrise industry in the country. During the processing more than 50% of the material goes as waste. Thus, waste disposal and its utilization is a challenge.

The fruit industry waste contains mainly cellulose, starches, pectins, vitamins, minerals and other micronutrients. These waste can be used for oil, animal feed, fuel, manure and some value added products like pectins, tartaric acid, citric acid etc. Table 11 gives the different waste material and their possible value added products.

Table 11: By-products of horticultural produces and their possible uses

Produce	Waste	Possible uses
Mango	Peel, stone, kernel trimmings	Starch, fat, vineagar kernel flour, animal feed, manure, besides medicinal use to cure diarrhoea, piles etc.
Guava	Seed, core, pomace	Ethanol, oil from seeds, pectine, animal feed
Grapes	Stem, pomace, peel, seeds	Seed oil, cream of tartar, tannin, wine fertilizer
Citrus	Peel, seed, pomace	Molasses, peel oil, cosmetics, soap, textile, pectine, wines, citric acid

Check Your Progress Exercise 4

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Why sorting at farm level is preferred?

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2. How sanitary conditions are maintained during washing?

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3. How waxing of fruits and vegetables enhances shelf life?

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4. List the properties of ideal fruit package.

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5. "Moisture is torture to fruits". Explain?

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6. Why blanching is done prior to drying?

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5.13 TECHNO-ECONOMIC FEASIBILITY

Some product base techno-economic feasibility has been given. The plant capacity can be enhanced or some other products can be taken up with the same machines.

5.13.1 High Moisture Products like Fruit Jam, Jelly, Preserve, Canned Slices etc.

Plant capacity	100 kg/day
Land	20 × 25 m
Constructed area	12 × 15 m
Cost of machines	Rs. 5,00,000/-
Rolling capital	Rs. 75,000/-
Quality control klaboratory	Rs. 1,00,000/-
Essential utilities	Food grade water Liquid waste water disposal system Electric power
Other utilities	Assured quality raw material Approachable Telephone
Rate of return	25% +
Break even point	45%

5.13.2 Intermediate Moisture Products like Raisin, Figs, Fruit Bar etc.

Plant capacity	100 kg/h
Land	20 × 25 m
Constructed area	10 × 15 m
Cost of machines	Rs. 6,00,000/-
Rolling capital	Rs. 1,20,000/-
Quality control laboratory	Rs. 1,00,000/-
Essential utilities	Food grader water Electric supply Liquid waste disposal system
Other utilities	Telephone Quality raw material Approachable
Rate of return	17% +
Break even point	About 60%

5.13.3 Dehydration Plant

Plant capacity	1000 kg/day
Land	20 × 25 m
Constructed area	15 × 15 m
Cost of machines	Rs. 10,00,000/-
Rolling capital	Rs. 2,00,000/-
Quality control laboratory	Rs. 1,00,000/-
Essential utilities	Food grade water Electric supply Solid and liquid effluent disposal system
Other utilities	Telephone Quality raw material Approachable
Rate of return	21%
Break even point	62 % (about)

5.13.4 Tomato Processing (Juice, Sauce, Ketchup, Puree)

Plant capacity	1000 kg /day
Land	20 × 25 m
Constructed area	12 × 15 m
Cost of machines	Rs. 6,00,000/-
Rolling capital	Rs. 1,00,000/-
Quality control laboratory	Rs. 1,00,000/-
Essential utilities	Food grade water Quality raw material Effluent disposal system
Other utilities	Electric power, approachable , telephone
Rate of return	23 %
Break even point	65%

5.13.5 Fruit Juice, Concentrates and Beverages

Plant capacity	500 kg/day
Land	20 × 25 m
Constructed area	15 × 15 m
Cost of machines	Rs. 10,00,000/-
Rolling capital	Rs. 125,000/-
Quality control laboratory	Rs. 75,000/-
Essential utilities	Food grade water Effluent disposal systems Electric power
Other utilities	Approachable Assured quality raw material Telephone
Rate of return	35%
Break even point	50%

5.14 LET US SUM UP

Fruits and Vegetables are of immense significance to man. Their nutrition, taste helps in good health in a human being. In the present scenario where horticultural production has increased many folds in last few decades but due to poor post harvest management losses has also increased. It is estimated that losses in fruits and vegetables amounts to be Rs. 67,000 crores annually. The main places where losses or damage initiate in the horticultural produce are on the plant itself, harvesting time, handling and storage. These losses can be minimized by pre and post harvest treatments and post harvest management. Surplus produce can be diverted for the processing, which will also create employment.

5.15 KEY WORDS

Climacteric Fruits : Those fruits that develop total senescence sometime after the harvest during storage. Fruits having higher respiration rate, produces of carbon dioxide and ethylene more than the non-climacteric fruits.

Pentrometer : Instrument to measure firmness of produce

Refractometer : Instrument to measure total soluble solids in the produce

Sorting : Removal of damaged, diseased, immature or over mature produce.

Blanching : Heat treatment given to the produce prior to the drying to inactivate enzymes, stabilize product and facilitate easy drying.

Sulphiting : Soaking (30 minutes) in the solution of potassium meta bisulphite prior to drying to maintain the colour.

5.16 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Any three fruits: Banana, Mango, Papaya, Sapota
   Any three vegetables: Cauliflower, Pea, Okra

2. Reasons for huge post harvest losses are:

   i) Poor infrastructure facility at the production site.
   ii) Poor post harvest handling and transport facility.
   iii) Less awareness about safe harvesting, sorting and grading at farm level.

3. Reasons for poor farm yield compare to International benchmark are:

   i) Poor planting material
   ii) Unplanned farm management practices.

Check Your Progress Exercise 2

1. Fruits and vegetables are major source of nutrition (minerals and Vitamins) so they are called protective foods.

2. Penetrometer

3. Refractometer

Check Your Progress Exercise 3

1. In Apple – bitter pit
   In potato – hollow heart
   Due to low calcium content – in tissue

2. Steps of safe harvesting are:

   i) Use proper tool to harvest, bag-to collect and crate during handling
   ii) Containers used should be clean, smooth, free from rough edges
   iii) Avoid hand touching of the fruits
   iv) Keep produce free from soil contamination
   v) Keep harvested produce in shade

3. Fruits and vegetables respire and release the heat. The rate of respiration is high at higher temperature. It reduces the shelf life of the produce. So they are cooled.

Check Your Progress Exercise 4

1. Sorting at farm level helps in reducing the cost incurred in the transporting and handling of unwanted produce. Moreover, damaged and immature produce respire more and release more heat. Thus, it may spoil other adjoining produce.

2. Sanitary conditions can be maintained by treating with water containing 100 –150 ppm chlorine.

3. Waxing of perishables reduces the rate of respiration and checks water loss thus, it enhances the shelf life of the produce.

4. Ideal fruit package should have

   i) Sufficient mechanical strength to withstand dead load during transportation. (Including impact and vibrations)

   ii) Good aeration to remove respiration heat and humidity.

   iii) Be attractive and economical.

5. Moisture in the fruits triggers the chain reactions of microbial activities, so moisture is a torture.

6. Blanching helps in drying by evacuating the air from pore spaces, and stabilize the product from microbial load.

5.17 SOME USEFUL BOOKS

1. Chakraverty, A., Mujumdar, A.S., Raghavan, G.S.V. and Ramaswamy, H.S. (2003) Hand Book of Postharvest Technology of Cereals, Fruits, Vegetables, Tea and Spices. Marce; Dekker Inc., New York.

2. Anonymous (1990) Home Scale Processing and Preservation of Fruits and Vegetables. CFTRI Publications, Mysore.

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7. Earle, R.L. Unit Operations in Food Processing. Pergamon Press, New York.

8. Bhatti, S. and Varma, U. (1997) Fruits and Vegetables Processing. CBS Publishers and Distributors. New Delhi.

9. Ranganna, S. (1995) Hand Book of Analysis and Quality Control for fruits and Vegetables Products. 2nd Edition. Tata McGraw Hill Co. Ltd., New Delhi.

10. Srivastava and Sanjeeb Kumar (1994) Fruits and Vegetables Preservation Principles and Practice. International Book Distribution Co. Lucknow.

UNIT 6 DAIRY, POULTRY, MEAT AND FISHERIES

Structure

6.0 OBJECTIVES

After reading this unit, you should be able to:

- state the present production status and importance of livestock products including fisheries in national economy;
- enumerate important value added products from milk;
- indicate steps for clean milk production;
- give the basic features of poultry management and preservation of eggs and meat;
- indicate important preservation and processing techniques for meat;
- differentiate between the culture and marine fisheries; and
- outline the principles of preservation and processing of fish.

6.1 INTRODUCTION

Animal husbandry, dairying and fishery activities along with agriculture have been an integral part of human life since the beginning of civilization. Man has been domesticating animals either for food or for cultivation and transport. These domestic farm animals or livestock such as, dairy cows/ buffaloes, goat, sheep, beef cattle, horses, pigs, chicken and turkeys play an important role in the socio- economic life of India. Livestock products play a pivotal role in improving the livelihood of a large number of people by providing food products and by-products for human utility. Besides providing high quality foods such as milk, eggs, meat, fish etc; the livestock sector provides employment to millions of rural farmers and people engaged in secondary and tertiary business related to it. The unit gives a profile of important livestock products in reference to food processing industries.

6.2 PRODUCTION AND ECONOMIC IMPORTANCE

6.2.1 Production

India has vast resource of livestock and poultry. India ranks first in respect of cattle and buffalo, second in goat, third in sheep and seventh in poultry population in the world. The country has 57% of the world's buffalo population. Table 6.1 gives the livestock population details and a profile of livestock products, i.e. milk, eggs, meat and fish is given in Table 6.2, 6.3 and 6.4.

Table 6.1: Livestock population

(million nos.)

Sl. No.	Species	Livestock census		Growth rate (%) 1997 over 1992 annual (comp.)	
		1992	1997		
1.	Cattle	204.58	198.99	-2.79	-0.56
2.	Buffalo	84.21	89.91	6.77	1.32
3.	Sheep	50.78	57.29	12.82	2.44
4.	Goat	115.28	122.71	6.45	1.26
5.	Pigs	12.79	13.29	3.91	0.77
6.	Others	3.22	3.28	1.86	0.37
Total Livestock*		470.86	485.36	3.08	0.61
7.	Poultry	307.07	347.11	13.04	2.48

** - excludes pack animals, yaks and mithuns*

Source: Annual Report (2003-04), Dept. of Animal Husbandry & Dairying, Ministry of Agriculture.

Table 6.2: Production and availability of milk and eggs

Particulars	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
Milk (million tones)	72.1	75.4	78.3	80.6	84.4	86.2	88.1	91.00
Per capita availability (gms/day)	207	213	217	220	225	230	231	232
Eggs (Million numbers)	28689	29476	30447	36632	38729	39823	40403	41000
Per capita availability (nos./head/ annum)	30	30	32	36	38	39	40	41

Source: Compiled from Basic Animal Husbandry Statistics 2004, Dept. of Animal Husbandry & Dairying

Table 6.3: Meat production – 1997 to 2003

(in 000 Tons)

Year	Beef & Veal	Buffalo Meat	Mutton & Lamb	Goat meat	Pig meat	Poultry meat	Total Meat
1997	1378	1403	222	458	533	630	4626
1998	1401	1380	226	462	543	710	4721
1999	1421	1398	228	466	560	821	4894
2000	1442	1421	229	467	578	1081	5218
2001	1452	1428	230	469	595	1251	5426
2002	1463	1443	233	470	613	1401	5622
2003	1490	1471	234	473	630	1600	5898

Source: Compiled from Basic Animal Husbandry Statistics 2004, Dept. of Animal Husbandry & Dairying

Table 6.4: Production and export of marine products

Year	Fish production (million tonnes)			Export of marine products	
	Marine	Inland	Total	Quantity ('000 tonnes)	Value (Rs. crore)
1950-51	0.5	0.2	0.7	20	2
1960-61	0.9	0.3	1.2	20	4
1970-71	1.1	0.7	1.8	40	35
1980-81	1.5	0.9	2.4	80	235
1990-91	2.3	1.5	3.8	140	893
2000-01	2.8	2.8	5.6	503	6296
2001-02	2.8	3.1	5.9	458	5815
2002-03	3.0	3.2	6.2	521	6793
2003-04 (P)	3.0	3.4	6.4	412 (P)	5739

Source: Economic Survey (2004-05)

Requirement: The per capita animal protein availability is about 10 grams as against minimum requirement of 20grams (from milk 10g, meat 4g, fish 4g, egg 2g). The estimated demand for the present population would be milk 104 million tonnes, meat 7.7 million tonnes, fish 7.7 million tonnes and eggs 4.6 million tonnes (104 million number). A significant gap exists between the requirements and production.

Milk Production: India continues to be the largest producer of milk in the World. The milk output during 2003-04 was anticipated to be 88.1 million tonnes and is expected to reach the level of 91.00 million tonnes during 2004-05. The per capita availability of milk is also expected to increase to 232 g per day during 2004-05 from 207 g per day in 1997-98.

Egg Production: Poultry development in the country has shown steady progress over the years. The current production of eggs is estimated to about 41.00 billion (in numbers) during 2004-05. Currently India ranks fifth in egg production in the World.

Fish Production: There has been significant growth in fish production in the country in the recent years. India is now the third largest producer of fish in the world, and second largest producer of fresh water fish in the world. During the year 2002-03, the total fish production was 62.00 lakh tonnes comprising 30.00 lakh tonnes of marine fish and 32.00 lakh tonnes of inland fish. The fish seed production during the year 2002-03 was 16,333 million fry. Fish is a source of cheap animal protein and current per capita consumption of fish in India is around 9 kg per annum as compared to 11 kg recommended by World Health Organization (WHO).

Meat and Meat Products: Though the country has a good livestock population yet most animals are not bred/ reared in industrialized or scientifically controlled methods for meat production, which is reflected by a generally low annual slaughter rate across all species except pig. Most of the production of meat and meat products continues to be in unorganised sector. The share of bovine meat in the total meat production is about 60% as against small ruminants (sheep and goats – 15%), pigs (10%) and poultry (12%). There are about 3,600 licensed slaughter houses operating in the country, most of them being run and maintained by local municipal bodies. Overall, the scenario is: abattoir management is poor, technologies employed are out of date and hygiene and sanitary conditions are not perfect. As per FAO data the per capita / year meat consumption is 5.2 kg.

6.2.2 Economic Importance

Employment Generation: Animal Husbandry sector provides large self-employment opportunities. According to National Sample Survey Organization's latest survey (1999-2000), the estimate of employment in animal husbandry sector was 11 million in principle status and 8 million in subsidiary status, which is 5% of the total working population. Women constitute 71% of the labour force in livestock farming. Poultry provides employment to about 1.5 million people. The fisheries sector provides employment to over 11 million people. About 0.5 million women are employed in pre and post harvest operations in marine sector.

Value of Output: According to estimates of the Central Statistics Organization (CSO), the value of output from livestock and fisheries sectors together was about Rs. 1,86,094 crores at current prices during 2002-03 (Rs.156, 080 crores for livestock sector and Rs. 30,014 crores for fisheries). The livestock and fisheries sectors contributed 6.5 percent of total GDP(5.4 percent from livestock and 1.1. percent from fisheries) in 2003-03.

Export Earnings: Total export earnings from livestock, poultry and related products were Rs. 4734 crores in 2003-04. Out of the total exports, leather sector accounted for Rs. 2568 crores in value terms.

Export Potential of Marine Products: There has been steady growth in the export of fish products. During 2001-02, the country exported 4.58 lakh tonnes of marine products, which resulted in export earning of Rs. 5815.00 crores. Efforts are being made to boost the export potential through diversification of products for export. The country has now also started export of frozen squid, cuttle fish and variety of other finfishes. During 2002-03, the country has exported 5.21 lakh tonnes of marine products valued at Rs.6793.05 crores.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Give the milk production and per capita availability of milk for the year 2002-03.

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2. Give the cattle and buffaloes population as per 1997 livestock census.

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3. List the economic importance of animal husbandry sector.

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6.3 DAIRY

We know that the milk is the lacteal secretion of the mammary glands of animals. Milk provides both energy and the building material necessary for growth. It also contains antibodies which protect the young animals against infection. In short, milk is a complete food in itself and nature has designed it as a food for the young ones during the first period of life. Let us know more about milk.

6.3.1 General Characteristics of Milk

The principal constituents of milk are water, fat, proteins, lactose (a type of sugar) and minerals (salts). Figure 6.1 shows the important constituents of milk in brief.

The milk of different species, although containing- the same constituents in general, varied in composition and properties in minor ways. Table 5 gives the composition of milk of a few mammals. Milk constituents are divided mainly into three groups namely, water, fat and solid-not-fat (SNF). Milk contains on an average 87 per cent water, 3.9 per cent fat, 4.9 per cent lactose, 3.5 per cent protein and 0.7 per cent minerals, vitamin and other constituents. Milk of ruminants like cow, buffalo and goat is ideally suited for human consumption and meet the basic dietary requirements of human beings.

Table 6.5: Average composition of milk from various species

Species	Constituents %					
	Fat	**Proteins**	**Lactose**	**Ash**	**Total Solids**	**Water**
Cow	4.0	3.4	4.6	0.74	13.64	86.36
Buffalo	7.3	3.8	4.9	0.78	16.78	83.22
Goat	4.0	3.7	4.5	0.85	13.05	85.95
Sheep	6.2	5.2	4.7	0.90	17.00	83.00
Camel	3.0	3.9	5.4	0.74	13.04	86.96
Human	3.5	2.0	6.8	0.30	12.60	87.40

Please incorporate the concept and role of co-operatives in milk production following account may help:

In India ‘White Revolution’ was brought due to operation Flood, largest dairy project for increased milk production in world. The key role in its success was played by “Co-operatives” a concept introduced by Dr. V. Kurien, father of white revolution small co-operatives at village level that involved the participation of farmers (milk produces) and collection centre (processors) was mutually helpful. Today almost all states have ‘Milk Co-operatives’ with AMUL (Anand Milk Producers Union Ltd.) becoming a global brand.

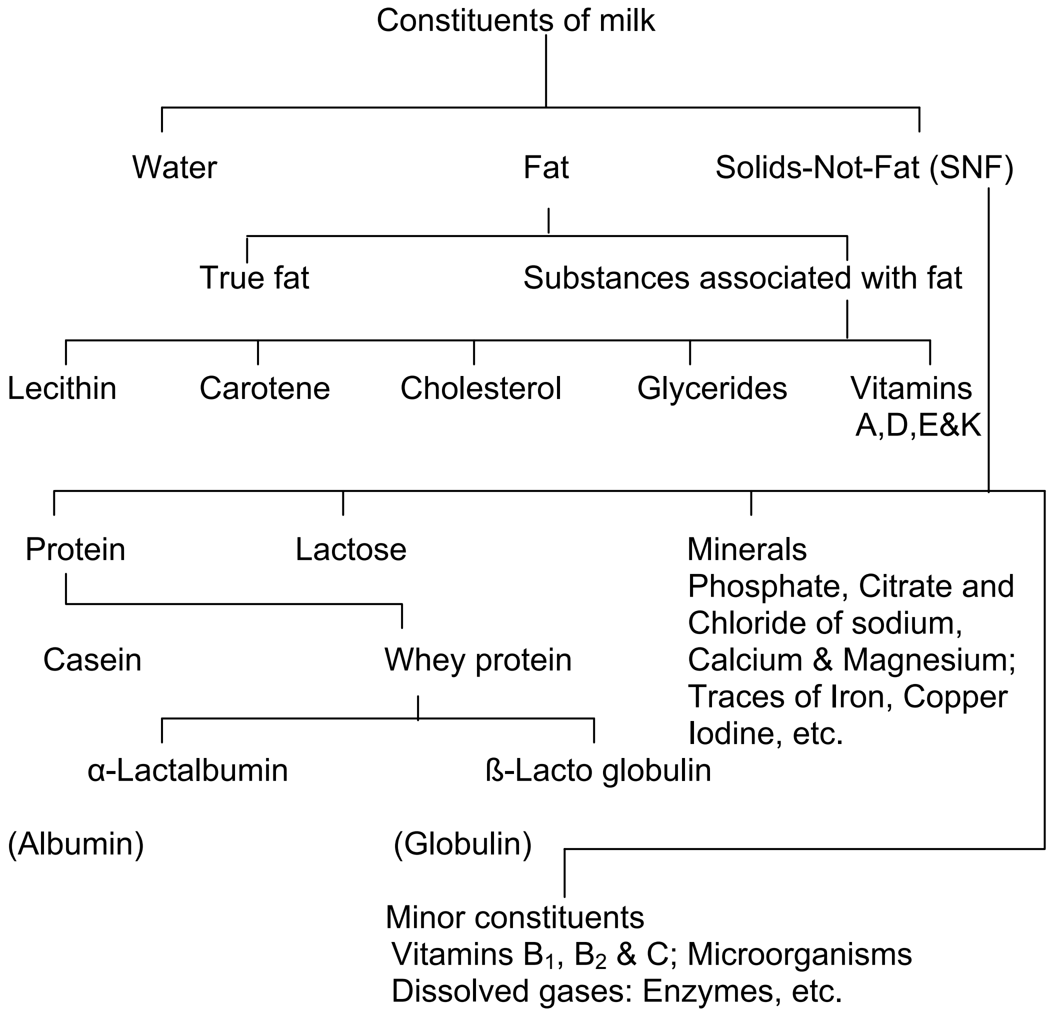

Figure 6.1: Milk constituents

6.3.2 Nutritional Importance of Milk

We know that the milk is recognized as almost an ideal food. It has high nutritive value. It supplies body- building proteins, bone- forming minerals and health giving vitamins. Lactose and milk fat furnish energy. Besides supplying certain essential amino acids and fatty acids, it contains the nutrients in an easily digestible and assimiliable form. All these properties make milk an important food for pregnant mothers, growing children, adolescents, adults, invalids, convalescents and patients alike. The nutritional importance of milk is significant with reference to our country as large population is vegetarian and for them milk & milk products are the only source of animal proteins. Besides, human milk has immunoglobuling, lactoferried, lysozyme and bifidus factor. These Bioprotective attributes make it a perfect food for infants. It's been clinically established that breast fading is best for infants.

6.3.3 Clean Milk Production

Milk is virtually sterile in the udder of a healthy animal. Milk once secreted becomes the target for contamination during milking, milk handling, transport and storage. The degree of infection and the composition of the bacterial population depends on the cleanliness of the animal's environment and the cleanliness of the new surface with which the milk comes into contact, e.g., the pail or milking machine, the strainer, the tanker or the tank and agitator. The bacteria can also get into the milk via the milker, the animal, the litter and the ambient air. Initially high bacterial counts and rapid growth of microorganisms will badly affect the keeping quality of the raw milk and the quality of products manufactured from such milk. Milk contaminated with pathogenic bacteria may be harmful to human health. Therefore, all possible measures should be taken to limit the contamination of milk and to prevent further bacterial growth. The quality aspects are gaining importance and emphasis is on the Clean Milk Production (CMP). The important steps for clean milk production are:

i) Clean and healthy animals: The cow's body especially the udder, should be washed and brushed before milking. Diseased animals should be kept separately.

ii) Clean Housing: Sheds, mangers, paddocks, water trough, floor should be clean and there should be good drainage.

iii) Fly proof milking parlour.

iv) Disease-free environment: milker with clean habits (nails well trimmed).

v) Clean Utensils, Milking pails.

vi) Clean water.

vii) Clean milking: Before milking, clean the udder with a cloth dipped in antiseptic solution such as potassium permagnate; wetting of hands with milk should be avoided.

6.3.4 Basic Milk Processing

Milk after being received at dairy plant is subjected to various unit operations. A few basic processing operations to which the milk is subjected are given here.

Reception and storage of milk : Each milk processing plant or chilling centre where milk is received in raw or chilled condition, requires a separate area for milk reception, commonly known as Raw Milk Reception Dock (RMRD). Milk is received at the dock either in cans directly from the producers / collection points or in insulated tankers from the chilling centres. The steps involved in the process are given in Figure 6.2.

Steps involved in Milk Reception at the Dock (RMRD)

In cans	**In tankers**
1. Unloading	1. Weighing
2. Grading	2. Grading
3. Weighing	3. Sampling
4. Sampling	4. Unloading
5. Dumping	5. Cleaning of tankers
6. Cleaning of cans	

Figure 6.2

The milk is chilled as early as possible in order to check the growth of organism present and maintain the keeping quality of milk. The chilled milk is stored in storage tanks or silos (large storage vertical tanks).

Milk separation: The process of separating out cream from milk is known as separation. It is based on the principle of difference in specific gravity between the fat (0.90-0.93) and the serums or solid-not-fat (1.027-1.036). This can be done either by gravity or by applying the centrifugal force. The dairy plants use 'Centrifugal Cream Separators' in which centrifugal force is applied to enhance rate of skimming, i.e. separating force is multiplied many times than that of gravity and the separation takes place more completely and instantaneously.

Pasteurization: Pasteurization is a process applied to a product with an object of minimizing possible health hazards arising from pathogenic micro-organisms associated with milk by heat treatment, which is consistent with minimal chemical, physical and organoleptic changes in the product. The term pasteurization as applied to market milk today refers to process of heating every particle of milk to at least 63° C (145° F) for 30 minutes or 72° C (161° F) for 15 seconds (or the temp-time combination which is equally efficient) in an approved and properly operated equipment. After pasteurization milk is immediately cooled to 5° C (41° F) or below. LTLT (Low temperature long time) is suitable for small quantities ranging from 200-1000 litre requiring low initial cost of production. HTST (High temperature short time) treatment is ideal for large scale handling of 5000 litres per hour (LPH) or higher. The complete process of preheating, heating, holding, pre-cooling and chilling is completed in a plate type heat exchanger mounted on a compact frame with inter connected sections to make the process continuous. Phosphatase test is carried out to determine whether milk has been properly pasteurized or not.

6.3.5 Milk Products

We know that milk is a rich source of nutrients and is an essential part of diet. Milk is a unique biological fluid which can be dehydrated, concentrated, coagulated, fermented and fractionated into a vast range of milk products. The popularity and consumption of milk products is constantly increasing in our country. Nearly, 50% of the total milk production is converted into various milk products. The focus is being given to value addition and international quality assurance to the indigenous dairy products as tremendous potential has remained untapped. A profile of few popular indigenous and western products is given here.

Butter: A fat rich dairy product obtained from churning milk, cream or curd and working the grains thus obtained into a compact mass. The butter making process involves a number of stages. Churning is the key step and it involves giving violent medium agitation which breaks the emulsion of fat in serums and induces the clumping of fat globules. It is a perishable product, and therefore, it should not be stored longer than necessary. For short period butter can be stored at 4° C but if longer storage is involved it must be stored at −21 to −29° C.

Concentrated and Dried Products: Drying the milk is an efficient method of preservation. In addition, drying also greatly reduces the volume of milk, which is an advantage for long distance transportation and extended storage. Alternatively, only part of the water can be removed from the milk and water activity is further decreased artificially increasing the amount of dissolved solids. This is done by dissolving sugar in a milk concentrate. Accordingly, on the industrial scale milk is preserved by drying or evaporation. The representation composition of these products is summarized in Table 6.6.

Table 6.6: Composition of preserved milk products

Product	Fat%	Milk solid not fat %	Sucrose (%)	Water (%)
Milk powder				
Skim	1	95.5	–	3.5
Whole	26.5	71.0	–	2.5
Evaporated Milk				
Unsweetened	8	18	–	74
Sweetened	8	20	45	27

Cheese: It is defined as a product made from the curd obtained from milk by coagulating the casein with the help of rennet or a similar enzyme in the presence of lactic acid produced by adding starter culture and from which part of the moisture (whey) has been removed by cutting, cooking and pressing. The concentrated solids thus obtained are shaped in a mould and then ripened by holding it at suitable temperature (8-10° C) and humidity. There are many varieties of cheese in the world today that are differentiated by thousands of name. Moisture content of cheese serves to distinguish various categories such as hard, semi-hard, and soft. Cheddar cheese, processed cheese, mozzarella and cottage cheese are quite popular in our country.

Frozen Dairy Products: Ice-cream is a popular frozen dairy product made by rapid freezing of pasteurized mix with agitation to incorporate air and ensure uniformity of consistency. As per PFA definition, the product should contain not less than 10% milk fat, 3.5% milk protein and 36% total solids. It may contain permitted stabilizer and emulsifier not more than 0.5%.

Khoa: *Khoa* or *Mawa* is an important traditional milk product of India. It is prepared by partial desiccation of cow or buffalo or mixed whole milk in an open fire. It is used as the base in several milk sweets viz. *burfi, kalakand, peda, milk cake, gulab jamun,* etc. As per PFA rules, the khoa is the product obtained from cow or buffalo (or goat or sheep) milk or a combination thereof, by rapid drying. The milk fat content shall not be less than 20% of the finished product. In our country, khoa of three varieties, viz. *Pindi, Dhap* and *Danedar* is produced. *Pindi* type of khoa has lowest moisture content. Product obtained from buffalo milk is considered superior being whiter in colour and having soft smooth body and granular texture.

Chhana: It is a popular indigenous milk product obtained by acid coagulation of hot milk followed by draining of whey. According to PFA, the product shall contain not more than 70% moisture and not less than 50% fat on dry matter basis. *Chhana* is used as a base and filler for preparation of a large number of sweets such as *rasogolla, sandesh, ras-malai*, etc. Cow milk *chhana* with moist surface, light yellow colour, soft body, smooth texture and mild acidic flavour is more suitable for Bengali sweets preparation than buffalo milk *chhana*.

Ghee: Ghee is the most important traditional Indian milk product being extensively used for dietary and religious purposes. Cow ghee is golden yellow in colour whereas buffalo ghee is greenish in colour. Ghee is characterized by its pleasant, cooked and rich flavour. The preferred texture is of large uniform size grains uniformly distributed throughout the lot. Ghee produced at different places and different conditions vary in quality. It is refined by heating in large pans at 70-80°C, the product being allowed to settle for 2 to 5 hours after removing the scum formed at the top.

Dairy By-Products: A byproduct may be defined as a product of commercial value produced during the manufacture of a main product. Skim milk, whey and butter milk are the industry's principal byproducts, residues from the manufacture of cream, cheese and butter, respectively.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Give the average composition of cow milk.

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2. Enumerate the important steps involved in clean milk production.

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3. Define pasteurization.

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6.4 POULTRY

Poultry keeping in our country is as old as our civilization. Red jungle fowl found in India and its neighbouring countries is considered to be progenitor of all domestic breeds of fowl. Now, we include ducks, geese, turkeys, pheasants, pigeons, peafowl, guinea fowl and chickens in the list of species under the general term poultry. Chicken, the most popular domesticated poultry, account for more then 90% of the total poultry population of the country. The poultry provides us eggs and chicken.. Rural backyard poultry contributes about 30% of the egg production. The Govt. of India has taken a new initiative of development of rural backyard poultry with a more holistic and self-reliant approach. Let us know more about eggs and poultry.

6.4.1 Poultry Production

The current poultry population in the country is above 435 million and accounts for 4% of the world poultry. The common breeds are shown in table 6.7.

Table 6.7: Common poultry breeds

S. No.	Breed	
1.	American Breeds	Plymouth Rock, Rhode Island Red, New Hampshire
2.	Asiatic Breeds	Brahma Cochin Langshan
3.	Mediterranean Breeds	Leghorn Minorca
4.	English Breeds	Cornish Australorp
5.	Indigenous Breed	Aseel Busra Chittagong, Kadaknath

The important economic traits in reference to rearing of poultry at small scale for egg purpose are - egg production, egg weight, egg quality, body size and confirmation, growth, feed efficiency and fertility and hatchability. Production economics of a commercial layer (for egg purpose) is entirely different than that of a commercial broiler (chicken purpose). The main attributes of a commercial layer are high egg production, low body size, less feed consumption, optimum egg size, good egg quality and high mobility and of a commercial broiler are high juvenile body weight especially at the marketing age, better feed efficiency and low brooder house mortality.

Hatching of Eggs: Hatching is production of baby chicks from fertile eggs. In early days eggs were hatched by placing them under broody hens and desi hens were ideal for this purpose. At present, incubators are used to hatch eggs. They provide similar environment as that of broody hens but more efficiently. Incubators can hatch several thousands egg at a time. The physical factors necessary for successful incubation are temperature, humidity, gaseous environment and turning of eggs. The incubation temperature usually varies from 37.2 − 37.8º C (99.5º F to 100.5º F). In fowls, the hatching period is 21 days. For obtaining better hatch and healthy chicks, the incubators and hatchers should be neat, clean and free from microbial load and should function properly.

6.4.2 Poultry Management

It refers to the husbandry practices to maximize the efficiency of production by satisfying the basic needs of the birds. It involves the management of chicks, layers and broilers.

a) *Chick Management:* It is also known as brooding management. The chicks are transferred to a brooder house immediately after hatching and reared there for 6 to 8 weeks of age. Brooder house should be draft-free, rain-proof and protected against predators. Suitable litter material like saw dust and paddy husk should be spread to a depth of 5 cm. depending upon their availability and cost. Right temperature in a brooder house is very essential. Too high or too low a temperature slows down growth and causes mortality. During the first week the temperature should be 95º F (35º C) which may be reduced by 5º F per week during each successive week till 70º F (21º C). The behaviour of chicks provides good indication of whether they are getting desired amount of heat. Infrared lamps are also good for brooding. Plenty of clean and fresh water should be provided.

b) *Grower Management:* The objective of the growing phase is to produce a pullet (young hen) which will come to lay around 20 weeks of age with an average body weight of 1.2 to 1.4 kg. Grower management especially remains the same as that of chick management except for the additional floor, water and feeder space. The floor, water and feeder space required for a grower are 950-2350 cm^2, 1.5 to 2.5 cm. and 7.5-12.5 linear centimeter, respectively. Water is essential and its requirement depends upon temperature, humidity, age, dietary constituents, activity and air movement. Deworming is essential and is done bi-monthly to keep the birds free from parasitic diseases. De beaking is recommended between 12 and 16 weeks. Feed restriction is essential to reduce the feed cost and productivity.

c) *Layer Management:* The flock should be transferred from grower to layer house at 18 to 20 weeks of age. Floor space of 2300-2800 cm^2, feeder space of 10 cm. and water space of 2.5 cm. per bird are recommended for egg type chicken in floor house. One laying nest for every 4 pullets is necessary. A platform in front of the nest entrances helps the birds to have access to the nest. From 21 weeks, the lighting should be increased gradually till it reaches 16-17 hours per day and maintained at that level thereafter. Correct lighting boosts up egg production by 5 to 10 percent.

d) *Male Management:* Breeder mate management remains essentially the same as that of layer management except that male breeder's diet should be fortified with extra calcium, manganese and vitamin E to ensure proper fertility.

e) *Housing:* The objective of providing housing to poultry is to protect from sun, rain and predators. Poultry houses should be well ventilated, reasonably cool during summer and warm in winter. In our country, open-sided poultry houses are popular. The poultry house should not be expensive. The floor should be moisture proof, free from cracks, easily cleaned, rat-proof and durable.

f) *Feeding of Poultry:* Feeding constitutes an important concern in poultry management since major expenditure (60-70%) in poultry raising is feed cost. More than 40 nutrients are required. The birds should be given balanced ration, i.e. supply different nutrients – i.e. fat, carbohydrates, proteins, minerals, vitamins and water in right proportion. Conventional poultry ration include many cereals like maize, rice, wheat, barley and a few by-products such as wheat barn or rice polish, animal and vegetable protein sources like fish-meal, meat-meal, soyabean-oil-meal, groundnut cake, etc. The ration is fortified with adequate quantity of minerals and vitamins either in chemically pure form or through ingredients known to be rich in these nutrients. Efforts are being made to use agro-industrial products to replace more costly ingredients.

6.4.3 Composition and Nutritive Value of Egg

The main parts of an egg are shell (8-11%), albumen (56.61%) and yolk (27-32%). Egg contains about 2 parts white to 1 part yolk by weight. The whole mixed egg contains about 65% water, 12% protein and 11% fat. The composition of the white and the yolk differ considerably. The yolk is rich in fat, fat soluble vitamins A,D,E, and K and in phospholipids including the emulsifier lecithin (Table 6.8)

Table 6.8: Chemical composition of the hen's egg

Fraction	%	% of Constituents			
		Water	Protein	Fat	Ash
Whole Egg	100	65.5	11.8	11.0	11.7
White	58	88.0	11.0	0.2	0.8
Yolk	31	48.0	17.5	32.5	2.0
Fraction	**%**	**Calcium carbonate**	**Magnesium carbonate**	**Calcium phosphate**	**Organic matter**
Shell	11	94.0	1.0	1.0	4.0

Nutritionally, eggs are a good source of fat, protein, vitamins and minerals, especially iron. It is often used as a standard for measuring the quality of other food proteins. Its high nutrient content, low calorific value and easy digestibility make it a valuable protective food in human diet.

Quality Factors

The important quality attributes of eggs are: egg size, cleanliness and soundness of shell, albumen and yolk quality, nutritive value, wholesomeness, functional properties, etc. Egg size can be adversely affected by inadequate level of protein and essential fatty acids in layer's (hen's) diet and high environmental temperature.

The quality of egg starts deteriorating soon after it is laid unless proper care is taken to maintain it following better methods of assembly, cleaning, grading, packaging, storage, transport and distribution. Fresh eggs have a high yolk rather than a flat yolk and a larger amount of thick white relative to running thin white. This causes a stale egg to spread out over a larger area than a fresh egg. Fresh eggs taste better, are nutritious superior, are easier to separate into whites and yolks for manufacturing purposes, and perform better in whipping and baking applications. Storage is best at a temperature slightly above the freezing point of the egg. For short period of storage, fresh eggs could be stored at 12.5º C to 15.5º C (55-60º F) and 70-80% RH. For long term storage, the room temperature should be at – 10º C (14 $\pm$ 1º F) and RH 80-90% as this relative humidity will sufficiently retard evaporation without danger of mould growth.

6.4.4 Preservation of Shell Eggs

Preservation of shell eggs are based on simple principle of retarding the microbial growth and sealing pores of the shell to minimize the evaporation of moisture and escape of gases. The common methods include i) thermal processing, ii) immersion in liquid, iii) oil-coating, iv) cold storage, and v) pickling.

In flash heat treatment, the eggs are immersed for 2 to 3 seconds in water at 71º C. The treatment destroys bacteria present on the surface of shell and seals the shell internally by coagulating a thin film of albumen immediately below the shell membrane. Oil treatment preserves the egg by forming a thin film on the surface of shell and thereby sealing the pores. This treatment should be given preferably within a few hours of lay to retain better internal quality. The eggs should be washed before coating. The oil used must be colourless, odourless, less viscous and free from fluorescent materials. Eggs can be dipped in oil or sprayed with it. Vegetable oils such as groundnut oil mixed with 0.0125% BHT is a good sealing agent, but the mineral oils of food grade are preferable as they are less susceptible to oxidative changes during storage. Under village conditions, immersion in lime water and water glass is also useful. In lime sealing, the eggs are immersed in clear lime solution (prepared by using quick lime, water, table salt) and then taken out. Eggs are dried at room temperature and transferred to filter flats.

Dehydration and freezing are the commonly used methods for the preservation of liquid whole egg, albumen and yolk separately, depending upon their use in bakery products, confectionaries and other food or non-food products.

6.4.5 Processing of Poultry Meat

Poultry meat has high nutritive value. It is easily digestible and its protein content is in general higher and fat content lesser than in most of the red meats. Chicken meat contains all the essential amino acids and quantitatively compares closely with milk and egg proteins. It has less carbohydrate, but is a good source of Vitamin B, iron and phosphorus.

The scientific and hygienic processing of poultry is must for processing the quality of meat. Figure 6.3 gives the flow sheet for preparation of ready-to-cook chicken. These are packed immediately either in polyethylene bags of medium density (200 gauges) or vacuum packaged in heat shrinkable film bags.

Procurement of Birds

Handling period (withdraw feed only)

Ante-mortem inspection

Killing-bleeding

Scalding (58º - 60° C for 1 to 2 minutes)

Defeathering

Singering

Hand finish

Evisceration

Post-mortem inspection

Washing and cleaning

Chilling (in slush ice to 4° C or lower)

Draining

Packaging

Chill storage at 2° C (to be sold within a week or 10 days)	Frozen storage at - 18° C after freezing at - 40° C (for storage up to 9 months)

Figure 6.3: Flow sheet for the preparation of ready-to-cook chicken

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What is brooding?

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2. Give the composition of white egg and yolk.

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3. Enumerate the methods for preservation of shell egg.

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6.5 MEAT

We know that the word "meat" in its broadest sense means the flesh of animals, especially of mammals or birds rather than fish. However, the term in reference to food processing includes all those parts of the animals that are used as a food by man, and covers glands and organs such as tongue, liver, heart, kidney, brain and so on besides the skeletal tissue or flesh. In our country, sheep, goat, pig and poultry are reared primarily for meat production. Though meat has a very high biological value, its production and processing has always been the subject of social considerations. The per capita animal protein availability is about 10g as against the World average for 25g. Considering the targeted minimum requirement of 20g per capita per day for animal protein, 4g will come from meat remaining 16g from other livestock products. The estimated demand of meat for the present population would be 7.7 million tonnes as against the present production of 5.7 million tonnes. The meat is not an essential item of diet for a large population of the country. The annual meat production of the country is about 4-6 million tonnes and we are placed at number eight position in the world. .

We export both frozen and fresh chilled meat to more than 54 countries in the world. There is, however, very little processing of meat (1%) for ready to eat meat products. About 40 million people are engaged in meat sector, namely, trade of live animals, hides, bones, caesings, horns and hooves, etc. This sector when organized on scientific lines will generate more employment in rearing of animals on scientific lines and processing of slaughter house byproducts for allied industries. The country is poised to achieve the Pink Revolution through buffalo rearing for meat production. A brief profile of meat production and meat products in reference to food technology is given below.

6.5.1 Structure and Composition of Meat

Meat is predominantly composed of muscle tissue along with various types of connective tissue. A cut of meat consists of lean tissue, which, aside from water, is chiefly protein, with some fatty tissue and bone. Muscle is composed of bundles of hair like muscle fibers. These protein muscle fibers are held together by proteniaecous connective tissue which merges to form a tendon which in turn connects the muscle to bone. The connective tissue contains two proteins called collagen and elastin. Collagen on heating in the presence of moisture dissolves and yields gelatin. Elastin is tougher and is a constituent of the ligaments. In well fed animals, fat penetrates between the muscle fiber bundles and this is fat marbling. There are relationships between muscle structure and meat technology. Thinner muscles fibers are tenderer than thicker muscle fibers, and thinner muscle fibers are more common in young animals. Marbled fat within the muscles makes for more tenderness.

Composition of Muscle Tissue: Muscle tissue contains approximately 75% water and 25% solids, of which 19% are proteins. Lipids constitute about 2.5% to 5% of muscle. It contains Cu, Zn, Na, Hg, K, Mg and low amount of Ca. Most of the calcium in the body of an animal is found in the bones, so the edible portion of meat is low in this mineral. Liver is an especially rich source of iron and a concentrated source of Vitamin A. Meats are excellent source of niacin and riboflavin and are good source of thiamine.

6.5.2 Nutritive Value

Meat is a very nutritious food. It is almost fully digestible. The nutritive value of meat is attributed to its abundant high quality proteins, essential fatty acids, some important minerals and B complex group of vitamins (thiamine, riboflavin, niacin, pantothenic acid, B_6, folic acid, biotin and B_{12}). Calories supplied by meat vary with the contents of fat. Organs such as tongue, brain, thymus (sweet breads), heart, liver and kidney are called variety meats. They are also excellent source of nutrients. Variety meat (organ meat) especially liver and kidney contain appreciable amounts of vitamins A, B, C, D, E and K.

6.5.3 Production of Wholesome Meat

The essential stage requiring applications of effective measures for production of quality meat are:

i) Animals should be given sufficient rest before slaughter.

ii) Ample drinking water should be available to them and about 1 hour before slaughter, they should be given very little to eat but should not be starved.

iii) The weak and diseased animals should not be slaughtered. Only those animals which produce carcasses of quality and nourishment should be slaughtered.

iv) Slaughtering and bleeding of the animals should be done without causing excitement.

v) The carcass unfit for human consumption should be destroyed.

vi) Ensure environmental sanitation during transportation of meat and it is safe to the public.

vii) Ensure personal hygiene of all those engaged in slaughtering, dressing and handling of meat.

viii) Process equipment should be kept thoroughly clean and disinfected before use.

ix) Meat and meat products should be stored in fly-proof containers. These must be refrigerated during summer.

Slaughter Houses or Abattoir: Slaughter houses or abattoir means any premises that is approved and registered by the controlling authority in which animals are slaughtered and dressed for human consumption. Abattoir may be small, medium or large based on the number of animals slaughtered. Based on the level of technology adopted the operations are manual, semi-mechanized or fully automatic. The slaughter houses play an important role in the processing of animals for production of safe and wholesome meat and in the effective recovery of by-products.

The important sections of the modern abattoir are (a) Lairage for resting the animals prior to slaughter; (b) slaughter hall; (c) By-product room; (d) Meat cutting room (optional); and (e) Rendering room (optional) or simple system of treating offals or condemned carcass. The building should be furnished with fly- proof system, sufficient lighting, ventilation and water supply (Fig.4). Let us appreciate that application of modern scientific methods for processing of meat in abattoirs would provide safety, value addition, convenience and consumer satisfaction. The Govt. of India has initiated a number of programmes for improvement and modernization of slaughter production.

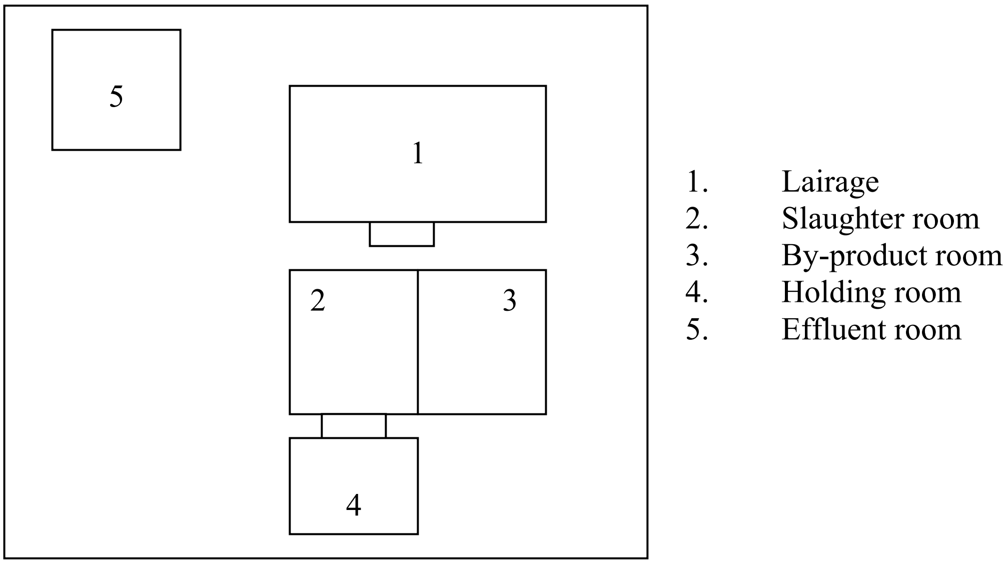

Figure 6.4: Slaughter house

Towards this end, we as trained technicians, should ensure for humane methods of slaughter and production of meat under hygienic conditions. Slaughtering of animals in unconscious state will facilitate prevention of cruelty. The essential processing steps in abattoir are: i) resting animals in lairage prior to slaughter; ii) ante-mortem inspection; iii) stunning (depends on religious customs); iv) slaughter and bleeding on the cradles; v) skinning, dressing and evisceration on the overhead rail; vi) post – mortem inspection; vii) washing; and viii) holding the carcass in chill room (optional); ix) cutting and packing (optional).

6.5.4 Preservation Techniques

Meat is a highly perishable commodity due to nearly neutral pH (low acid food), high moisture contents and rich nutrients. Various methods to extend the shelf-life of meat are: i) chilling / refrigeration; ii) freezing; iii) curing; iv) smoking; v) thermal / processing; vi) canning; vii) dehydration; and viii) irradiation.

Refrigeration/chilling: This is the most widely used method of preservations for short terms storage of meat. Storage of fresh meat is done at a refrigeration temperature of 2 to 5^0 C. Fresh meat can be maintained in good conditions for a period of 5-7 days at a refrigerated temperature of 4 ± 1^0 C. The cooling slows down the microbial growth and enzymatic as well as chemical reactions. Processed meat products are also stored under refrigeration till these are fully consumed.

Freezing: It is for the long terms preservation of meat. It stops the microbial growths and retards the action of enzymes. Large quantities of meat and meat products are stored, distributed and marketed in frozen form. A product can be considered frozen when its centre has a temperature of -12^0 C or less. The speed of freezing is a very important factor as frozen meat quality depends mainly on the size of the ice crystals formed. The quality of meat and meat products can be preserved for months together during frozen storage at -10^0 C. However, a storage temperature of -18^0 C is recommended because at this level almost all water in meat is frozen and minor fluctuations can be taken care of.

Curing: Preservation of meat by heavy salting is an age old practice. Sodium chloride and sodium nitrite are commonly used. Now a days curing of meat products is mainly for specific flavour and colour development and preservative effects of curing ingredients is an added advantage.

Smoking: Smoking helps in preservation of meat. It contains a large number of wood degradation products such as aldehydes, ketones, organic acids, phenols, etc. which exert bacteriostatic effect besides imparting characteristic smoky flavour.

Thermal processing: Thermal processing as a preservative method is employed to kill the spoilage microorganisms as against the refrigeration methods that slows or stop microbial growth. Pasteurization and sterilization are common heat processing operations that are generally used.

Pasteurization refers to moderate heating in the temperature range of 58^0 C to 75^0 C. The process extends the shelf life but the product needs to be stored under refrigeration. Sterilization refers to severe heating above 100^0 C whereby all spoilage microorganisms in meat are killed. It renders the product commercial sterile. Such meat products have a recommended shelf life of two years in cans and one year in retort pouches at ambient temperature in tropics.

Canning: It is a process of preservation achieved by thermal sterilization of a product held in hermetically sealed containers. The product have a shelf life of at least 2 years at ambient temperature. The steps involved are (i) Preparation of meat and gravy, (ii) Precooking of meat, (iii) Filling in cans, (iv) Exhausting, (v) Seaming, (vi) Retort or thermal processing, (vii) Cooling and (viii) Storage.

Dehydration: Removal of water from meat lowers the water activity considerably to prevent the growth of spoilage organisms. Freeze drying of meat is a satisfactory process of dehydration preservations due to better reconstitutions properties, nutritive quality and acceptability. Freeze dried products are packaged under vacuum and have very good storage stability. The process has been largely used for preparations of the dehydrated meat soup mixes.

Irradiation: Food irradiation is referred as cold sterilization as microbial destruction of foods take place without significantly raising the temperature of food. A doze of 50-100 k rad (radurisation) can enhance the shelf – life of fresh meat cuts and poultry products by 19 days whereas a doze of 4-5 M rad (radurisation) can sterilize pork, poultry and fish.

6.5.5 Meat Products

Meat cutting: Meat cutting refers to the skill of separation of carcass into wholesale primal cuts in order to facilitate requirements of meat trade, cater to the consumer preference and convenient handling by the butchers. The basic requirements in cutting are:

i) The carcass has to be essentially chilled for proper meat cutting and trimming job.

ii) Meat cutting room should be maintained at a temperature of 15-20^0 C and relative humidity of 80%. This environment is wholesome for meat and convenient to workers.

iii) All the meat cutting equipment and machinery should be made up of stainless steal and be sufficiently sharp.

iv) Cutting methods varies from country to country. Bureau of Indian Standards (BIS), specify the division of carcass into right and left sides. In our country, people go for six cuts only – neck, shoulder, rack, foreshank and breast, loin and leg.

Tenderizing meat is another important operation which is done by using mechanical methods, enzymes and salt. It affects palatability of meat.

Type of products: Meat products include a variety of products such as sausages, cured and smoked meat products (ham, bacon), canned meat (canned beef, luncheon meat, canned hams) and cooked meat products (patties, kababs, meat balls, nuggets). The purpose of meat processing to products are primarily preservations by inhibiting or preventing spoilage, improving the palatability and providing variety for trade. Meat processing to products facilitates utilization of certain cuts from the carcass which are having poor utility otherwise. The processing also help in development of convenience products for consumers. Economics of meat processing rests with the ability to utilize fats and other carcass trimmings and low value carcass cuts and by products to produce acceptable products.

Nature and role of ingredients: Meat quality plays an important role. Additives such as water or ice, salt, phosphate, nitrate, nitrite, sugar and anti-oxidants are added to improve product quality characteristics during processing. Ice chills meat during chopping or mixing operations and prevents mechanical over-heating, helps in dissolving salts, gives fluidity and facilitates proper filling. Salt reduces microbial growth, solubilizes muscle protein and imparts taste. Phosphates increase water holding capacity, fat binding, emulsion stability and ensure decreased cooking losses. They have a synergistic effect in improving the quality of meat products in combination with 1 to 2 % salt, and are used at 0.5 % level. Sugar at the level of 0.5% is added to provide flavour, mask the salt flavour and act as a preservative. Spices and condiments such as onion, ginger, black pepper, cloves, etc. are also used to improve flavour and taste of the meat products.

Processing methods: Processing refers to any treatment including salting which brings about a substantial chemical and physical changes in the natural state of meat. The preservatives processes such as curing, smoking, cooking, canning, freezing, dehydration, are also used in meat product preparations. Processing imparts considerably shelf stability to meat. The common processing techniques in reference to meat product preparations include: (i) comminution, (ii) emulsification, (iii) meat extension, (iv) pre-blending, (v) hot processing and (vi) cooking.

Meat products: Meat products are classified into the following groups

i) Cured and smoked meats
ii) Sausages
iii) Intermediate moisture and shelf stable meat products
iv) Restructured meat products
v) Canned meats
vi) Other meat products

Ethnic meat products: The range of popular products include, meat curries with gravy, fry or *pulav* (with rice) kababs (*sheek kababs, shami kababs, boti kababs), tandoor products* (tandoor chicken), grilled products and pickles.

By-products: Animal by-products are available from live animals, slaughtered animals and dead animals. The returns from the by-products are also important as meat forms only one–third of live weight of the animal while by-products from two–third. Utilization is important not only to ensure cost-effective utilization process but also for proper disposal to prevent environmental pollution and adverse effect on the main enterprise. Edible by-products from slaughtered animals include blood, variety meat, organ meats (tongue, heart and liver), casing and bones. Non–edible by-products include blood (blood meal), bones (bone-meal, ossein), horns and hooves, gastro-intestinal contents (feed, fertilizers), glands (hormones) and bile (bile salts). Dead animals are also a significant source of useful by-products when collected and processed. Hides and skins, horns and hooves, bones and bone – products, meat-meal and technical fat are the useful products from dead animals.

Among the animal by-products leather and leather products, bone and bone products, and woollen carpets are the major items of export. Other by-products those are exported include animal casings, edible offals, bile paste, gallstones and bristles. Animal glands and organs, viz. ovary, testis, pituitary, adrenal, pineal, parathyroid, thyroid, thymus, spleen, bile, lungs, liver, stomach, brain, spinal column, and seminal vesicles are utilized for medicinal and pharmaceutical purposes.

Check Your Progress Exercise 4 ✍

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. State the measures for production of quality meat.

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2. List out various methods used to extend the shelf life of meat.

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3. Name some of the value added products prepared from meat.

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6.6 FISHERIES

Fish is a valuable food due to presence of high quality proteins, i.e. presence of essential amino acids and fat (high proportion of poly unsaturated fatty acids - PUFA); rich source of B group of vitamins namely thiamine, riboflavin, niacin and pantothenic acid and important minerals such as iodine, phosphorus, active iron and sodium. The composition of flesh of fishes is (a) water 80%, (b) protein 15-25%, (c) mineral matter 1-2% and (d) other constituents 1%. The consumption of fish and fish products is continuously increasing. The nature has bestowed on India a wide variety of fishes. The aquatic endowment is supporting more than 2200 fishes, out of which nearly 1440 species are marine species, 143 species are brackish species, 544 warm water species and 37 are cold water forms. Let us know more about fish production, preservation and processing.

6.6.1 Growth rate

The country has witnessed a quantum jump in the fish production. The country occupies third position in the world and second position in the inland fish production. The fish production is the fastest growing sector in the agriculture. As compared to agriculture and animal husbandry, the fish production rate per unit area is much higher in terms of productivity as well as income. The growth rate of 2.5 percent and 8.0 percent has been proposed for marine and inland fisheries, respectively during the tenth plan. By the end of tenth plan, this will enable a total fish production of about 8.2 million tonnes with 3.3 million tonnes coming from marine sector and rest from inland sector.

Fish is a highly perishable food and therefore due importance be given for marketing, processing, preservation and keeping quality of fresh fish. Lowering, the temperature of fish from 10° C to 0° C, delays the growth phase of micro-organisms that are present and cuts the spoilage by a factor of 5 to 16. Therefore, the fresh fish should be refrigerated (near 0° C) immediately.

6.6.2 Culture Fisheries

The fish culture in ponds and paddy is an age old practice. A series of activities such as controlled breeding in captivity, production of quality seeds in sufficient quantities, rearing of spawn to fry stage, fry to fingerling stage and ultimately raising the table size are christened under the scientific fish farming. The induced breeding in captivity is widely used to get adequate quantity of quality seeds of major cultivated fishes. The process of releasing egg by female and milt by male is called spawning. The mature fishes are induced to breed by giving the pituitary injection. The hormone pellets are implanted into muscle during initial period of gender development for inducing maturation and spawning. Fishes having developed gonads are called brood stock. Hatchery management is an essential component under scientific fish farming. It involves supply of quality water, brood stock development, spawning operation, incubation of eggs, rearing of larvae from egg to post larval stage, nutrition and artificial feeding and health monitoring. The quality of water is very vital component for the survival and growth of larvae and post larvae. It is also important to maintain favourable temperature, water level, flow of water and adequate level of oxygen during larval rearing.

Construction of Fish Farm

The ponds are constructed to have high survival rate. The ponds are classified into nursery pond, rearing pond and stocking pond. The nursery ponds are used to nurse the spawn upto fry stage and are small and shallow. The rearing ponds are used to rear fry up to fingersling stage. The stocking ponds are used to grow the fish to marketable size. Generally, rectangular shape ponds are constructed with a depth of 0.5 to 0.10 m for nursery ponds, 0.6 to 1.5 m for rearing ponds and 1.0 to 2.5 m for stocking and brooder pond. An assured supply of good quality water free from pollution and turbidity is to be ensured. The pH of water should in range of 6.5 – 7.5 and for correcting the pH liming is done. The optimum concentration of dissolved oxygen (above 5 ppm) is maintained by adequate aeration by means of aerator, paddle wheel aerators, surface agitators and air blowers. The practice of using composite fish culture has revolutionized the aqua food sector in the country. The feed management and health management also play an important role in productivity.

Aquaculture has mainly contributed to the high growth of inland fisheries (6.6% per annum) as compared to marine fisheries (2.2% per annum) during the nineties. Indian major carps/ Labeo rohita (rohu), Catla catla (catla) and Cirrhinus mrigola (mrigalo) contribute about 78% of the total aquaculture production. The productivity has also gone up from about 600 kg/ha year in seventies to about 2000 kg/ha year.

6.6.3 Marine Capture Fisheries

We know that the country has a long coastline of 8118 km and an equally large area under estuaries, backwaters, and lagoons good for developing capture as well as culture fisheries. After declaration of the Exclusive Economic Zone (EEZ) in 1997, the area available to India is about 2.02 millions sq. cm. The harvestable potential of marine resources in EFZ has been estimated at about 3.921 million tonnes. The marine fishing fleet comprises about 0.281 million traditional craft (including about 44578 motorized traditional craft), 53684 mechanized chained craft and about 170 large fishing vessels of 21 m overall length (OAL) and more. The major fishing activities are concentrated in the areas within 0 to 70-80 m depth zone. Fish production has increased over the years with the motorization of traditional craft and introduction of mechanized boats in the traditional sector as well as diversification of fishing effort beyond 50 m depth.

As spoilage of fish starts from the time it is caught, the proper storage, preservation and prompt disposal or transport services are essential. The wastage is acute during monsoon when upto 30% of the catch is lost. Therefore, strengthening of post-harvest infrastructure such as storage facilities, ice plants, cold chains, roads and transportation etc., as well as effective marketing system in identified areas are the key requirements for the development of this sector.

6.6.4 Post Harvest Care

As we know fish is a highly perishable and decomposes quickly. The problem is acute in our country as heat and moisture promotes deterioration. Bacteria of water and air attack the flesh slowly at first and more rapidly later. Chemical changes cause breakdown of protein and other nitrogenous matter leading to the production of substances like hydrogen sulphate and indol. The characteristics odour of stale or spoiled fish is due to trimethyl amine which is formed by reduction of tri-methyl oxide. Fishes are preserved by various methods such as drying, salting, pickling, smoking, canning, chilling and freezing. Before preservation, fishes are washed with clean water to remove saline, blood stains, mud and sand. Larger fishes are gutted (i.e. on the internal organs or vice-versa are removed) and the body county is washed.

To remove natural moisture from the fish tissues, fishes are cured by means of heat, sun dry air and salt all along the coast. Drying of small marine fishes such as ribbon fish, silver bellies and Bombay duck in sun or shade is a very ancient method of fish preservation. In this method fishes are spread on the open sandy beach, mats, bamboo platform or hung on ropes/rods. Mechanical drier are also used for this purpose and this method yields high quality products which retains the nutritive value and flavour. Salting is a form of pickling in which common salt is used to prevent bacterial growth and methods of dry salting and wet salting are employed. In the dry salting method, fishes are rubbed with salt powder and than packed in the plastic/cemented tanks. In between two layers dry salt is applied and after stipulated period these fishes are removed, washed in the salt water and then dried. In wet salting method, gutted and cleaned fishes are placed in the container containing concentrated salt solution and stirred properly. Wet salted fishes are sold in the market without drying. In smoking, wood smoke is utilized as a preservative. In this method, cleaned and gutted fishes are soaked in the salt or brine for a short period and then suspended on rod in the smoke house. In chilling, fishes are packed in ice and then saw dust or rice husk is sprinkled over it to prevent the melting of the ice. Freezing is the most modern method of preservation. Fish intended for long storage are frozen in large deep freezers. Individual quick freezing method is gaining popularity. Frozen fishes retain their nutritive values for a longer time.

Value added products: A number of value added products are available in the market, viz. battered and breaded products like fish fillets, fish cutlets, fish cakes, fish burgers, fish balls, fish sausages, fish noodles, fish rolls, fish patties, stuffed squids, etc. The switch over from block freezing to individually quick frozen (IQF) products has changed the profile of value added products.

IQF provides, lobster, imitation products like kamabaka, crab legs, imitation shump are becoming popular. The value added products like (i) prawn and fish pickle, (ii) fish and prawn papad, (iii) fish jhuri bhagra, (iv) fish noodles and (v) fish pulp can be prepared dry woven fishers also. The techno-economic advantages of the products are (i) wide acceptability (ii) greater shelf life, (iii) more palatability, and (v) stringent quality control. There is a good potential for export of preferred products.

By-products and other uses: Fishes are also source of numerous byproducts such as (i) Fish oil, (ii) Fish-meal, (iii) Fish flour, (iv) Fish proteins, (v) Fish glue and singlass. Two important fish oils are (i) Liver oil and (ii) body oil. Liver oil is popularly known as cod-liver oil. There are numerous by-products besides oil, which are economically useful. The most important are fish-meal, fish-flour, fish-protein, fish-ghee and fish-skin.

Check Your Progress Exercise 5 ✍

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What is spawning?

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2. Enumerate the methods used for preservation of fish. Name a few value added products.

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3. Give the nutritional importance of fish.

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6.7 LET US SUM UP

The country has a considerable livestock population. Processing and production of value added products hold an important place in the national economy. We are the largest milk producers in the world. The quality of milk plays an important role in processing of milk and milk products. The important value added products from milk are butter, concentrated and dried milk products, ghee, cheese, frozen dairy products, *khoa, chhana* and a range of by products such as skim milk, whey, etc. The poultry provides us eggs and chicken. The major expenditure in poultry raising is feed cost. The methods used for preservation of shell eggs are based on retarding of microbial growth and sealing pores to minimize the evaporation of moisture and escape of gases. The meat production in our country is largely a byproduct system of livestock production utilizing spent animals at the end of their production life. Meat is a highly perishable commodity and methods to extend the shelf life are (i) chilling/refrigeration; (ii) freezing (iii) curing (iv) smoking (v) thermal processing (vi) canning (vii) dehydration and (viii) irradiation. The common indigenous popular products are meat curries with gravy, fry or *pulav* (with rice), *kababs* (*sheek kababs*, *shami kababs, boti kababs*), *tandoor* products (*tandoo*r chicken), grilled products and pickles. Fish is a source of cheap animal protein. It is highly perishable and various methods adopted for preservation are drying, salting, smoking, canning, chilling and freezing. Cod-liver oil one of the important by-products.

6.8 KEY WORDS

Preservation	:	Aims to inhibit microbial spoilage and arrest physio-chemical changes which bring about deterioration in quality.
Lactose	:	A type of natural disaccharide consisting of glucose glactose present in milk.
Brooding	:	Rearing of chicks upto 6 to 8 weeks of age.
Milk	:	It is the lacteal secretion of the mammary lands of animals.
Milk separation	:	The separation of milk into cream and skim milk.
Pasteurization	:	A process of heating every particle of milk or milk product to specified temperature and holding at that temperature for specified period followed by immediate cooling and storage at low temperature.
Hatching	:	Production of baby chicks from fertile egg.
Abattoir	:	Premises that is approved and registered by the controlling authority in which animals are slaughtered and dressed for human consumption
Comminution	:	It refers to subdivision or reduction of raw meat into meat pieces or particles.

Processing	:	Treatment or unit operations which bring about a substantial chemical and physical change in the natural state of milk/meat/fish/egg.
Post-mortem	:	It is the systematic exposure and scientific examination of the tissue and organ of a dead body to determine the cause of death, the nature of lesions and illness.
Aquaculture	:	The term relates to the culture of fish in fresh water, backlash water and sea water.
Spawning	:	The process of releasing eggs by female and wilt by male is called spawning.

6.9 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. The milk output during 2002-03 was 86.2 million tonnes and the per capita availability of milk during the period was 230 g per day.

2. Cattle population: 198.99 million and buffalo: 89.91million.

3. The livestock and fisheries sectors contributed 6.5 percent of total GDP (5.4 percent from livestock and 1.1. percent from fisheries) in 2003-03.The value of output livestock and fisheries sectors together was about Rs. 1,86,094 crores at current prices during 2002-03 (Rs.156, 080 crores for livestock sector and Rs. 30,014 crores for fisheries). Total export earnings from livestock, poultry and related products were Rs. 4734 crores in 2003-04.The sector provides large self-employment opportunities.

Check Your Progress Exercise 2

1. Milk contains on an average 87 per cent water, 3.9 per cent fat, 4.9 per cent lactose, 3.5 per cent protein and 0.7 per cent minerals, vitamin and other constituents.

2. The important steps involved in clean milk production are:
   - Clean and healthy animals.
   - The cow's body especially the udder, should be washed and brushed before milking. Diseased animals should be kept separately.
   - Clean Housing: Sheds, mangers, paddocks, water trough, floor should be clean and there should be good drainage.
   - Fly proof milking parlour.
   - Disease-free environment: milker with clean habits (nails well trimmed).
   - Clean Utensils, Milking pails.
   - Clean water.
   - Clean milking: Before milking, clean the udder with a cloth dipped in antiseptic solution such as potassium permagnate; wetting of hands with milk should be avoided.

3. The term pasteurization as applied to market milk today refers to process of heating every particle of milk to at least 63° C (145° F) for 30 minutes or 72°C (161° F) for 15 seconds (or the temp-time combination which is equally efficient) in an approved and properly operated equipment

Check Your Progress Exercise 3

1. Brooding is management of the chicks.
2. The composition is given in Table 6.9:

Table 6.9: Chemical composition of the white and yolk

Fraction	%	% of Constituents			
		Water	Protein	Fat	Ash
White	58	88.0	11.0	0.2	0.8
Yolk	31	48.0	17.5	32.5	2.0

3. The common methods of preservation of shell eggs include (i) thermal processing, (ii) immersion in liquid, (iii) oil-coating, (iv) cold storage, and (v) pickling.

Check Your Progress Exercise 4

1. The essential stage requiring applications of effective measures for production of quality meat are:
   a) Animals should be given sufficient rest before slaughter.
   b) Ample drinking water should be available to them and about 1 hour before slaughter, they should be given very little to eat but should not be starved.
   c) The weak and diseased animals should not be slaughtered. Only those animals which produce carcasses of quality and nourishment should be slaughtered.
   d) Slaughtering and bleeding of the animals should be done without causing excitement.
   e) The carcass unfit for human consumption be destroyed.
   f) Ensure environmental sanitation during transportation of meat and it is safe to the public.
   g) Ensure personal hygiene of all those engaged in slaughtering, dressing and handling of meat.
   h) Process equipment should be kept thoroughly clean and disinfected before use.
   i) Meat and meat products should be stored in fly-proof containers. These must be refrigerated during summer.
2. Various methods to extend the shelf-life of meat are: (i) chilling/ refrigeration; (ii) freezing; iii) curing; (iv) smoking; (v) thermal/processing (vi) canning; (vii) dehydration, and (viii) irradiation.

3. The value added products prepared from meat products are sausages, cured and smoked meat products (ham, bacon), canned meat (canned beef, luncheon meat, canned hams) and cooked meat products (patties, kababs, meat balls, nuggets)

Check Your Progress Exercise 5

1. The process of releasing egg by female and milt by male is called spawning.
2. Fishes are preserved by various methods such as drying, salting, pickling, smoking, canning, chilling and freezing. A few value added products are battered and breaded products like fish fillets, fish cutlets, fish cakes, fish burgers, fish balls, fish sausages, fish noodles, fish rolls, fish patties, stuffed squids, etc.
3. Fish is a valuable food due to presence of high quality proteins, i.e. presence of essential amino acids and fat (high proportion of poly unsaturated fatty acids - PUFA); rich source of B group of vitamins namely thiamine, riboflavin, niacin and pantothenic acid and important minerals such as iodine, phosphorus, active iron and sodium.

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UNIT 7 COMMERCIAL CROPS, SPICES, MEDICINAL AND AROMATIC PLANTS

Structure

7.0 OBJECTIVES

After reading this unit, you should be able to:

- state the importance of commercial crops, spices, medicinal and aromatic plants in the national economy;
- know about post harvest processing of these crops into value added products; and
- describe the by products and other uses of these crops.

7.1 INTRODUCTION

Commercial crops, spices and medicinal and aromatic plants are high value crops. These crops require special attention during production and also during post harvest processing, handling and storage. Some of these crops play a significant role in the national economy, export or in employing large number of people. Therefore, the study of these crops is to be separated from the other crops like cereals, pulses and oil seeds or horticultural crops.

The Unit 4 has been divided in three sections namely; commercial crops, spices and medicinal and aromatic plants. Under section 4.2 mainly two main commercial crops namely sugarcane and cotton are discussed. In the section

4.3, six major spices namely chilli, cardamom, pepper, tamarind, turmeric and ginger are discussed. Lastly medicinal and aromatic plants are discussed.

7.2 COMMERCIAL CROPS (SUGARCANE AND COTTON)

7.2.1 Importance

Crops, which are important from commerce points of view, are called commercial crops. Mainly two crops are considered as major commercial crops in India namely sugarcane and cotton.

Sugarcane is widely grown in almost every state of the country and two union territories. Sugar industry is the second largest processing industry in the country. There are more than 400 sugar industries in the country who receive raw material from 35 million sugarcane growers in the country. India is the largest sugarcane producer of the world and at one time (1975-76) it had exported over 1 million tonnes of sugar and earned Rs. 468.5 crores.

Wealth of Sugarcane: From energy transformation points, sugarcane is the most efficient crop. It receives the solar energy and converts it in to energy producing substances like sugar, cellulose and non-cellulose products. Thus its processing is valuable contribution to food and industry. Sugarcane produces sucrose which is a direct source of food and wide range of by products as shown in Figure 7.1. These products are useful for human and animal consumption and also provide huge renewable energy.

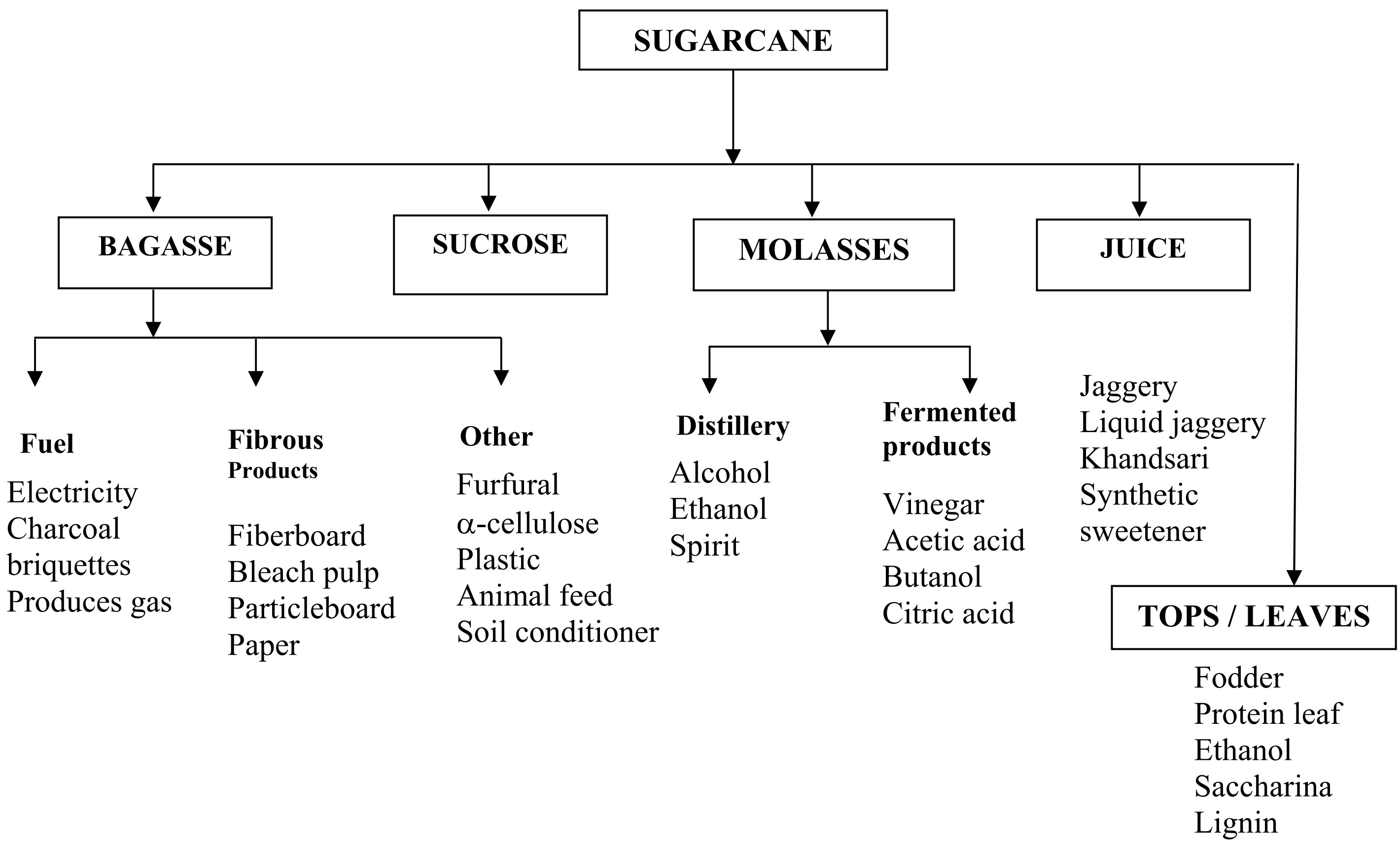

Figure 7.1: Products and by products of sugarcane

Cotton is the most important commercial crop playing a key role in economic, political and social fabric of the world. In India it is the biggest organized sector which provides employment to several million people. It is the largest industry in terms of annual value of output and labour employment. Besides this large number of power loom and handloom have employed around 2.5 million people.

Cotton is not only known for production of lint, which is the basic raw material of textile industry but also to produce cottonseed, which is rich in oil.

7.2.2 Processing of Sugarcane

In a typical sugar factory 100 tones of cane produces: Sugars (10 t), molasses (4 t), filter mud (3 t), Bagasses (30 t) and cane tops and leaves 30 t. Besides these it also can produce electricity of 1500 kW.

Juice Extraction

Sugar cane is crushed in sugarcane crusher (IS:1973-1973) in general where first dry crushing is done and about 73% of total available juice is recovered. Then wet crushing is done to recover remaining juice. IS-6983-1973 is the specification of rollers and axles for sugar cane crusher. Extracted juice is acidic (pH 5.2-5.5) in nature. It is neutralized to pH 6.4 by the addition of lime solution. In general in 100 kg juice, 1 kg lime (80-90% purity) is mixed with 4 litre of water and 60-75 ml of milk of lime is sufficient to bring desired neutralization.

Juice boiling: To avoid sugar inversion, the boiling should be done within 8-12 h of juice extraction. A traditional furnace, where *bagasse* is used as fuel should have high heat utilization efficiency and Juice clarification.

Jaggery

Jaggerry and *Khandsari* are ancient *sweetners* and still popular among masses for its high food value and medicinal properties. In India about 40% of sugarcane produced is used for making *jaggery* in the organized and unorganized sector. The *jaggery* is considered to be diuretic, refreshing tonic and cooling. Table 7.1 provides the comparison of composition of sugar, *Jaggerry* and *Khandsari.*

Table 7.1: Proximate composition of sugarcane sweeteners (100g)

Sweetener	Sucrose (g)	Reducing sugar (g)	Protein (g)	Fat (g)	Moisture (g)	Ca (mg)	P (mg)	Fe (mg)	Energy (Kcal)
Sugar	99.5	-	-	-	0.4	-	-	-	398
Jaggery solid	60-85	5-15	0.4	0.1	3-10	8	4	11.4	383
Khandsari	96	-	-	-	0.5	100	-	-	398
Bura	90-95	1-3	-	0.5	1.5	100	-	-	395
Misri	99.5	-	-	-	0.2	-	-	-	402

Source: Annual report of ISARI< Lucknow 1999-2000

The traditional process of *jaggery* preparation is shown in Figure 4.2. Sugarcane is crushed in sugarcane crusher. About 48 % of sugarcane mass as juice goes to clarifier. The clarified juice is boiled. To neutralize the juice lime is added and concentrated juice is put in the moulds (1, 5, 10 and15 kg). After cooling moulds are stored. Bagasse, which is a byproduct, is used as source of fuel in the *jaggery* preparations.

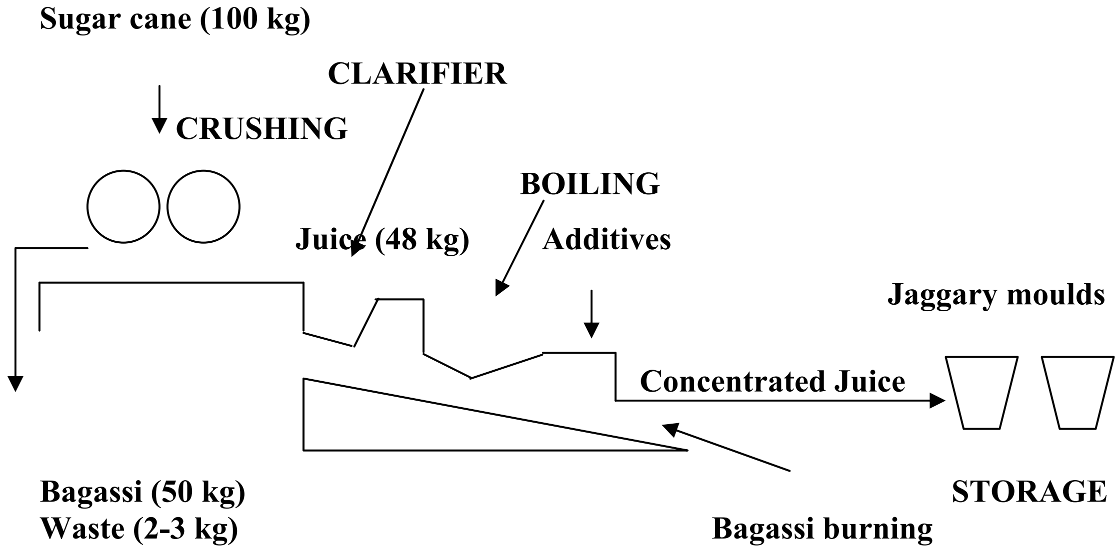

Figure 7.2: Traditional process for *jaggery* preparation

7.2.3 Byproducts of Sugarcane

Sugarcane plant has four major byproducts namely bagasse, molasses, sucrose, tops and leaves.

Bagasse

Bagasses, is the fibrous residue of cane stalk after crushing and extraction of juice. It consists water, fibers and small quantity of soluble solids. Its composition includes fiber 46-52%, moisture 43-52% sugar 3% and minor constituents 0.55%. Where as the dry bagasses composition is: Cellulose (45%), Pentosans (28%), Lignin (20%), Ash (2%) and sugar (5%).

Bagasse can also be used as –

i) **Pulp**: Bagasse can be converted in to pulp. This pulp can be used to make paper for wrapping, printing, writing, toilet, tissue, corrugated medium, linerboard etc. Fluff pulp can be used to make sanitary napkins and absorbent disposable products.

ii) **Paper Industry:** Process of paper manufacturing includes **digestion**, **washing, screening, bleaching, dewatering and thickening.** Bagasses are digested in close units at pre-specified pressure, temperature and time with chemicals. Later washing is done to remove the effect of chemicals.

iii) Fuel (briquettes, charcoal, produces gas)

iv) Fodder for animals

v) Production of mushroom

vi) Soil conditioner

Molasses Based Products

Molasses yield is 2.2 to 3.7% of the total cane crushed. It is graded based on total sugar content and yield of ethyl alcohol produced from it. Alcohol producing industry consume about 80-90% of the molasses produced in the country. The other important product is ethanol. The ethanol produced is used for

Ethanol

Dehydration	**Oxidation Dehydrogenation**	**Modification**
Polystyrene	Ethyl butyl acetates	Chloroform
Polyethylene	Acetic anhydride	Butadiene
Poly ethers	Charcoal	Diethyl then
	Butaaraldehyde	Ethylamines
	Acetamide	Ethyl chloride

Sucrose

Sucrose is a regenerable potential raw material obtained from sugarcane. Though it is not as sweet as saccharin, suralose, aspartame etc, but it has wide commercial applications. There are some added derivatives which have market potential such as:

- Ethers and anhydro derivatives
- Esters of fatty acids as surfactant and emulsifiers
- Sulfuric acid or sulphate esters.
- Polymers and resins, acrylics, etc

The other uses of sugarcane tops press mule and waste is in animal feed, fertilizer cane wax etc.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Why sugarcane is called energy efficient crop?

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2. Why cotton is the most important commercial crop?

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3. How much sugar can be produced from 1000 kg sugarcane?

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4. Why sugarcane juice is to be boiled with in 8- 12 hours of extraction?

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5. What are the medicinal properties of jaggery?

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6. List the unit operations are to be performed in paper manufacturing.

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7.2.4 Processing of Cotton

Ginning

It is an important unit operation in the handling cotton as a raw material from field to the factory for processing. It is the process of separation of lint from seed cotton. It is done either by roller gin or with saw gins.

Quality Evaluation of Cotton

The quality of cotton is judges by the quality of yarn which be spun from it. The spinning performance in expressed as **"Highest Standard Count" (HSC)** which cotton can spin. For i.e. 40 counts means one pound of a particular yarn contain 40 lakhs of 840 yards each. Based on the end-use of the yarn, certain strength standard have been prescribed. The maximum HSC for cotton is the finest count of yarn, which can be spun to satisfy the yarn strength standards. Thus important parameters are fineness, maturity and strength.

Fiber length – Longer lnited cotton provides better spinning performance than shorter linted ones.

Short staple	19 mm or below
Medium staple	20 .0 – 21.5 mm
Superior medium staple	22.0 – 24.0 mm
Long staple	24.5 – 26.0 mm
Superior long staple	27.0 mm and above

7.3 SPICES

7.3.1 Importance

The Indian spices are perhaps older than the recorded history. India is well known to the world as **Home of spices**. Spices contribute an important group of agriculture commodity as they are considered as indispensable in the culinary art for flavouring of foods. These crops will also show our heritage and national wealth in utilization of them for several medicinal uses. Some are also used as pharmaceuticals, perfumery, cosmetics etc. Besides this, spices play an important role in the national economy.

Chilli is the dried ripe fruit of genus "capsicum" which is also called as red pepper and it is considered as an important commercial crop used as a condiment, culinary supplement as a vegetable. In India, chilli is cultivated in about 10 lakh hectares with an annual production of 10 lakh tonnes, which is about one fourth of the world's chilli production. The annual Indian export of chilli in recent times is around 13000 tonnes valued about Rs. 500 million. Together with whole chilli, the value-added products like chilli powder, curry powder, chilli oleoresins etc. add a major share to our export earnings.

Among the various spices cultivated in India, cardamom is called "**Queen of spices**". It is native of India; enjoys a unique position in the International spice market. At present, India is the second largest consumer of small cardamom in the world after Saudi Arabia. The cardamom growing tracts in the country are facing severe ecological degradation due to diminishing forest cover, leaving the region open to devastation by floods and droughts. As cardamom requires tropical forest conditions for better growth, both the area and production of cardamom in the country are declining.

Pepper (*Piper nigrum*) popularly known as the **King of spices**. It is the dried fruit of perennial climbing vine, mostly found in hot and moist parts of Southern India. Kerala alone contributes 96% of the total production in India. Apart from Kerala, pepper is also cultivated in the hill districts of Karnataka and Tamil Nadu. Mostly pepper is cultivated as intercrop with other plantation crops.

Pepper is widely used as a condiment, preferred for its characteristic aroma, pungency and biting taste. It is used to garnish culinary preparations, ketchups, sauces pickles and in pharmaceutics. Indian pepper, commonly known as "Malabar pepper" is considered to the best in the world for its excellent aroma flavour and pungency. India is the largest producer, consumer and exporter of black pepper. India contributes about 35 to 40 percent to the total world production and thus occupies the unique position in the international trade of pepper. The annual production of pepper in India is in the range of 60,000-85,000 tonnes.

Tamarind (*Tamarindus indica* Linn) is one of the important economic trees of India. Tamarind is a much-loved tree throughout the semi-arid regions for its deep, cool shade and for its valuable fruit. It is an ideal plant for optimum use of wastelands. It is a regular bearer and provides assured returns to the farmers even under extreme soil and climatic conditions.

Turmeric adds typical flavour and colour in curries and makes them the best. Turmeric is also used as dye in textile industries, it is also used for medicinal purposes and cosmetics. India exports only 5-8 % of its turmeric produce and ranks 6^{th} in spice export and earns over Rs. 100 million annually.

India is the largest producer and exporter of pepper, chilli, ginger and turmeric. It also exports substantial amount of cardamom and black pepper. India alone contributes 50% of the world ginger requirement. Ginger is used principally as an ingredient in various spices blends, food processing and beverage industry.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are the indices to evaluate quality of the cotton?

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2. What should be the best quality fiber length?

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3. Name the following

   i) Home of spices : ………………………………

   ii) Queen of spices : ………………………………

   iii) King of spices : ………………………………

7.3.2 Proximate Composition of Spices

Spices are an important group of agriculture commodity as they are considered indispensable in the culinary art for flavouring of foods. These crops also show our heritage and national wealth. Some are also used as pharmaceuticals, perfumes, cosmetics etc. Proximate composition of spices is given in Table 7.2.

7.3.3 Harvesting and Drying of Chilli

The crop becomes ready for harvesting in about 105-120 days after planting. The picking of ripe fruits continues for about 2 months. Chilli is picked in about 6-10 pickings with an interval of 7 or 8 days. Some traditional varieties require only 5-6 pickings; while the hybrids may require up to 12 pickings. Harvesting is done after 1 or 2 days of irrigation and picked fruits are kept in shade to avoid sunscald.

Chilli is harvested at moisture content of around 60-70% (w.b.) and need to be dried for further preservation and storage. In the absence of efficient mechanical drying systems, currently all the chilli produced in the country is sun dried.

Table 7.2: Nutritional constituents of spices per 100 g

S. No.	Nutrient	Green Chilli	Red Chilli	Cardamom	White pepper	Turmeric	Ginger
1.	Carbohydrate	3.0	31.6	45.4	68.6		66.5
2.	Proteins	2.9	15.9	10.3	10.4	8.6	8.6
3.	Fat	0.6	6.2	8.3	2.1	8.9	6.4
4.	Fiber	6.8	30.2	9.2	4.3	6.9	5.9
5.	Moisture	85.7	10.0	8.3	11.4	58	5.9
6.	Minerals	1.0	6.1			6.8	
7.	Calcium	0.03	0.16	0.3	0.45	0.2	0.1

8.	Phosphorous	0.08	0.37	0.21	0.2	0.26	0.15
9.	Sodium			0.01		0.05	0.03
10.	Potassium			1.2		2.5	1.4
11.	Iron	0.0044	0.0023	0.012	0.017	0.05	0.011
12.	Ash			5.0	1.6		5.7
13.	Vit.A (IU) Vit – C Vit – B_1 Vit – B_2 Niacin	454 111	576 50	175 12 0.18 0.23 2.3	1800	175 49.8 0.09 0.19 4.8	175 12 0.05 0.13 1.9
14.	Calorific value					390	360

Source: NIN, ICMR, Hyderabad

7.3.4 Processing and Uses of Cardamom

As the flowering continues over a long period, cardamom capsules ripen successively over an extended period. Thus, it requires several pickings. In most of the areas, the peak harvesting is continued at an interval of 15 days and completed in 8 to 10 rounds

Harvesting should be taken up only at a time when seeds inside the capsules have become black in colour. It is the index of maturity stages of the fruit. At this stage the pericarp (the seed cover or skin of the capsule) will still be green. When light picking is done, great care is to be exercised to harvest only the green and mature capsules. This process will naturally give a lower green crop per picking. When the hard picking is done, semi-mature crop is also removed. While this process could reduce curing percentage, it could increase the picking average and ensure green coloured capsules.

Bleaching is an important pre-treatment given to either dried cardamom or freshly harvested capsules as starting material. The bleached cardamom is creamy white or golden yellow in colour. The advantages of bleached cardamom are white appearance and their resistance to weevil infestation due to sulphur dioxide content. Different methods to achieve bleached cardamom and are given in Table 7.3.

Table 7.3: Treatments for bleaching of cardamom

Treatment	Concentration of content bleaching agent	Contact time (min)	Remarks
Steeping in H_2O_2 containing 0.5% sodium silicate	6% H_2O_2	15	For dry cardamom
Bleaching with H_2O_2 and SO_2 fumigation	0.3%	60	Dry cardamom
Steeping in acidified powder solution	20 g/l	75	Fresh cardamom
Subsequent steeping in H_2O_2 containing 0.5% sodium silicate	1% H_2O_2	30	Fresh cardamom

Cardamom capsules should be dried within 24 to 36 hours of harvest to avoid deterioration. Drying is one of the important unit operations as it determines the colour of the end product, which is the attractive and most important quality character. The retention of green colour is very important in cardamom drying as green coloured cardamom fetches premium price in the export market.

Cleaning of cardamom by removing the discoloured ones, split capsules and other impurities is done by manual method. The grading of dried capsules as per AGMARK specifications is generally carried out using round sieves. Mostly 7 mm round holes sieves are used for grading.

Mainly cardamom has three products namely decorticated seed or seed powder, essential oil and oleoresin. The decorticated seed or its powder has poor storability, as volatiles are lost during the storage. Thus it is stored in pods. Cardamom oil is produced by steam distillation of crushed fruits. Cardamom is used as flavouring material as whole, decorticated seed and ground powder. It has medicinal value for scanty urination, diarrhoea, dysentery, and exhaustion due to over work, depression.

7.3.5 Post Harvest Technology of Pepper and its Products

The stage of harvest is very important for the production of black pepper. Well-matured but unripe berries are harvested. Pepper becomes ready for harvest in about 6-8 months after flowering, during November-December and harvest continues up to March-April. The spikes are picked when they are blackish green and most pungent.

Harvesting is done manually, by climbing on the ladders. The well-matured spikes, of dark green colour are picked by the person standing on the ladder and dropped. The person standing on the floor will collect the spikes in the bags. A pair of women will be able to pick about 90 to 100 kg of spikes and paid @ Rs. 1 per kg of berry picked.

The harvested green spikes are some times heaped for a day, before threshing for easy separation of the berries. In few estates, mechanical threshes are used for separating and cleaning the berries. However, the threshing efficiency of these machines is only about 90 percent. The freshly harvested berries contain moisture of above 70% (w.b.). The berries as soon as they are harvested are separated from spikes and spread out on mats for drying. In about 2 days, the moisture content decreases to 20-25%. Due to enzymatic oxidation of colourless compounds present in the skin, the colour of pepper fruits turn black and masks the green colour after drying. The subsequent operations involve further drying of safe moisture level below 11% (w.b.)

Since drying with periodic turning is commonly adopted, since it is feasible when the quantity is small and monsoon does not interfere. But for large scale drying, artificial drying is preferred. The moisture in partially sun-dried pepper is brought down from 25 to 11 % in two stages in a counter current hot air flow system. After one pass in dryer, the pepper is stored for 24-48 hours, after which it is dried again to safe moisture level.

The dried pepper is cleaned for removal of extraneous matter such as dirt, girt, stones, stalks leaves, etc. Magnetic separator is used to remove metallic contamination such as iron fillings and stray nails. Vibration conveyors with inclined decks in combination of air classification are used for efficient destoning of spices. The composition of the dried black pepper is given in the Table 7.4.

Table 7.4: Composition of the dried black peppe

Composition	Value in per cent
Moisture Content	8.7 – 14.1
Total Nitrogen	1.55- 2.60
Nitrogen in non volatile ether extract	2.7 – 4.22
Volatile ether extract	0.3 – 4.2
Non-volatile ether extract	3.9 – 11.5
Alcohol extract	4.4 – 12.0
Starch (acid hydrolysis)	28 – 49
Crude fibre	8.7 –18
Crude piperine	2.8- 9.0
Ash	3.6 –5.7

The ungarbled black pepper contains pinheads, immature pepper and large berries. Broken pepper and light pepper grades are separated pneumatically; pin heads which come along with garbled pepper are separated by sieving. As the export market potential for pepper is more, the market value can be increased by the removal of unwanted foreign materials.

Grading is done by a combination of size sieving and weight classification by air blast. The major grade is the average sized black pepper known as Malabar Garbled (MG), which constitutes 95% of India's export. Tellichery Garbled (TG) is another bold grade of black pepper. The recovery of black pepper from fresh berries is 33-36%. According to Agmark grading, grades have been formulated as given in Table 7.5.

Table 7.5: AGMARK specification of pepper

Pepper grade	Diameter (mm)
Tellichery Garbled Black pepper Special Extra Bold (TGSEB)	>4.75
Tellichery Garbled Extra Bold (TGEB)	4.25
Tellichery Garbled (TG)	4.0-4.25
Malabar Garbled Black Pepper (MG)	3.75
Malabar Ungarbled Black Pepper (MUG)	<3.75

Pungent principle

The alkaloid piperine (melting point 130^{o}C) is considered to be the major constituent responsible for pungency. It is not present in the leaves and stem. It is also not soluble in the water, readily soluble in alcohol and on hydrolysis splits into piperdine and piperic acids. Major adulteration in the black pepper is done with the papaya seeds. The best method to identify them is cut the seed in to two pieces. Papaya is a dicot, so it will show a line. Black pepper berries are monocot, have a hollow cavity in the center.

Processing of White Pepper

White pepper is the white inner corn obtained after removing the outer skin or pericarp of the pepper berries. It is preferred over black pepper in light-coloured preparations such as sauces, cream soups etc., whereas dark coloured particles are undesirable. White pepper imparts pungency and a modified flavour to food. White pepper is liked for its mellow flavour, mild pungency, low fiber, high starch content and above all the white colour itself is liked. Varieties like Balankotta and Panniyur-1, are ideal for making white pepper owing to their large sized berries. The composition of white pepper is given in Table 7.6.

Table 7.6: Composition of white pepper

Constituent	Water	Protein	Fat	Carbohydrate	Fiber	Ash
Content, (%)	11.4	10.4	2.1	68.6	4.3	1.6

Packaging

Black pepper berries are hygroscopic, so have to stored in cool, dry atmosphere away from sunlight. For retail packaging in 200 gauges HDPE pouches are used. Ground powder is packed in laminated heat sealed aluminium foil.

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. In India, chilli is mainly dried by …………………………………………...

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2. To get quality product of cardamom it should be dried with in …………….

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3. Pungent principal in the pepper is due to …………………………………...

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4. Main adulterant in the whole pepper is ……………………………………..

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7.3.6 Products and By-Products of Tamarind and their Uses

Tamarind is a forest tree. It is rarely grown as orchards. However, it is planted as social forestry. Every part of the tamarind is useful for human being as culinary or medicinal purposes.

Root: The root of tamarind is bitter and used in controlling the dysentery. It is cleaned, boiled and consumed or the powder is taken with water.

Stem bark: The stem bark is an astringent and a tonic. The bark is also used medicinally for loss of sensation in paralysis. The ash of the bark with salt is used as a remedy for colic and indigestion. A gargle of bark ash with water is used in sore throat to heal aphthous sores. The ash is given in urinary discharges and gonorrhea. The dry bark of the tree is peeled off for medicinal purposes. Usually it is done after the flowering season. The bark contains about seven percent tannin and is used in tanning industry.

Timber: The wood is hard, close-grained, yellowish white with red streak. The heartwood is small, near the center of the old trees and is dark purplish brown. It is a most valued timber for making tool-handles, agricultural implements, wheels, mallets, planks, furniture, rice-pounders, and oil and sugar crushers. It is also priced much higher as a fuel as it has high calorific value (4980) and chiefly used for making gun-powder, charcoal, and in brick kilns where great heat is required for brick-making.

Leaves: The tamarind leaves contain tartaric and malic acids. The latter is being found in excess and increasing with the age of the leaves. The leaves also contain certain enzymes. The leaves are astringent and the tender leaves are cooling and anti-bilious. A poultice of leaves is used as for inflammatory swellings and in rheumatism to relieve pain. Decoction of leaves is used for gargle, and juice is used in dysentery bilious fevers and in urinary troubles. The leaves yield a reddish yellow dye, which is used locally in colouring woollen and silk fabrics. The leaves and flowers are also used as auxiliaries in dyeing.

Flowers: The flowers of tamarind are also cooling and antibilious. Poultice of flowers is used in inflammatory affections of the conjunctiva. The juice extracted from flowers is used in cases of internal bleeding of piles.

Fruits: The fruits contain 55% pulp, 33.9% seeds and 11.1% shell and fiber. In India, the production of pulp is estimated at about 3,00,000 tons per year. Dry pulp of fruits yield about 16% of free tartaric acid and its salts along with Citric, Malic acids. Two kinds of pulp are known, the red coloured and the brown coloured. The former is having the superior quality. The pulp is non-proteinaceous and the pulp of tender fruits contains far less nitrogen than the ripe fruits. The pulp consists of crude protein 3.1%, carbohydrate 67.4%, fiber 5.6%, and minerals 2.9%. Chemical analysis of pulp give tartaric acid with potassium bi-tartarate 10-12%, moisture 20-30%, reducing sugars 25-30%, other solubles 3-4%, and the rest insoluble cellulose. Its vitamin contents are as follows: riboflavin 0.07mg, niacin 0.7mg and vitamin 'C' (3mg/100 g) and carotene (60 μ per 100 g). Of the reducing sugars present, about 70% is glucose and 30% fructose.

The pulp is edible and largely used for culinary purposes. The pulp contains tartaric acid, which is used as acidulent for soft drinks and fruit jellies. It is refrigerant, carminative and antibilious. It is also useful in preventing and curing scurvy and in sobering the intoxicating effects of alcohol and *Ganja (Cannabis sativa* Linn.). The pulp with wood-ash is extensively used for cleansing and brightening brass and copper vessels.

During storage, the reddish-brown colour of the pulp becomes darker and in about a year it is almost black. This is mostly due to the onset of Maillard reaction, since, free amino acids and reducing sugars are present in the pulp. The pulp also becomes soft and sticky as pectolytic degradation takes place and moisture is absorbed, especially in humid climates. The pulp could be preserved well for 6-8 months without any treatment, if packed in airtight containers and stored in cool and dry place.

Seeds: The seeds are used as famine food and for cattle in several districts in Tamil Nadu, Andhra Pradesh, Madhya Pradesh and elsewhere. The hard kernel is dried, roasted and powdered into flour and used for making cakes and chappatties, either alone or with flour of other edible kinds. The tamarind kernel powder can be fortified up to 15% in the preparation of bread and biscuit.

Industrial Uses

Tamarind Kernel Powder (T.K.P): Tamarind kernel powder is about 50% of the weight of the seeds. Commercial samples of T.K.P has the composition of : polysaccharides 48.7%, albuminoids 18.9%, fatty matters 7.5% moisture 8.8% ash 1.6%, soluble matters 3.2% and insoluble matters 11.3%. The commercial TKP finds extensive use as a sizing material in the textile industry. The sizing properties of TKP are due to the presence of a polysaccharide (called jellose) which is present to the extent of 6 percent.

7.3.7 Processing of Turmeric and its Uses

After harvesting the turmeric fingers are separated from mother rhizomes. Mother rhizomes are usually kept as seed material. Curing of green turmeric is done by boiling in the water with 20 g of sodium bi sulphite and 20 g of hydro chloric acid per 45.3 kg of tubers. It provides a yellow tint. The cured tubers are sun dried for 10-15 days till they become hard, brittle and produce metallic sound on breaking. Thereafter they are cleaned and then polished in a metallic drum rotated manually or by power. Generally dried cured turmeric is 20% of freshly harvested green rhizomes. It is also recommended that to develop attractive colour, half polished 100 kg turmeric rhizomes are mixed with the alum (0.040 kg), turmeric powder (2 kg), castor seed (0.14 kg), Sodium bisulphite (30 g) and concentrated hydrochloric acid (30 ml). After thoroughly mixing it is again dried in the sun.

Common products of turmeric are its powder, volatile oil and oleoresin. It is mainly used as food flavourant and colourant, cosmetics and as dye. It is used as medicine for stomachic, carminative, tonic, blood purifier, vermicide and antiseptic. Its powder is also used in tooth powder for relieving dental problem. It is also used as a face pack as it helps in clearing pimples and unwanted hairs.

7.3.8 Post Harvest Technology of Ginger

Freshly harvested ginger is cleaned with water to remove adhered soil, and then dried in the sun for 7-10 days. During drying, regular turning is required for uniform drying. After drying rhizomes are rubbed with the gunny bag to remove the remnants of the skin which results in smooth finish of the final product. In some places raw rhizomes are soaked in water and thick milk of lime (1kg slaked lime per 120 kg water). Some times the dried rhizomes are exposed to the sulphur dioxide fumes (3.2 kg of sulphur per tonne of rhizomes for 12 hours). It helps in bleaching the colour and results in white polished rhizomes.

The polished rhizomes are graded as per IS specification IS: 1908-1968. In general, indian ginger is graded in three grades namely (1) 3 fingerd rhizomes; (2) 2 fingered rhizomes and (3) pieces.

For the good quality of ginger its appearance, volatile oil content, fibre content, pungency, aroma and flavour are evaluated and compared with the standards.

In the rural India, ginger is heaped covered with the soil and ginger leaves in a shade. The heap may be plastered with the mud or cow dung. It can be stored well between 21-30^{o}C with 60-90 % relative humidity for two months. Scientifically ginger is stored in cold store at 2-5^{o}C with 90 % relative humidity for 4 months.

There various ginger products available in the market namely ginger oil, oleoresin, dehydrated ginger, bleached ginger, preserve, drinks, candy, pickle and wine. Besides this as a medicine it is considered as a stimulant and a carminative. It is also given in dyspepsia and flatulent colic.

Check Your Progress Exercise 4 ✍

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What is the use of tamarind flower juice?

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2. Name the acid which tamarind pulp has?

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3. Why the tamarind pulp becomes black during storage? How it can be checked?

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4. What is the industrial use of TKP?

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5. What is the use of turmeric base face packs?

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7.4 MEDICINAL AND AROMATIC PLANTS

7.4.1 Uses of Medicinal and Aromatic Plants

Medicinal plants are the local heritage with global importance. Indian herbs are principal form of medicine and presently popular throughout the developed world. Basically herbs work in combination with the body's own defense system. The human body is much better suited to treatment with herbal remedies than with the isolated chemical medicines. The chemical medicines after expiry may cause harm to the body whereas the natural products that have lost their active qualities are not harmful to the system. The digestive systems and physiology of human evolved utilizing capacity of plant based foods and medicines. Many plants provide food as well medicines for i.e.

i) Lemon improves resistance to infections.
ii) Papaya is used for expelling worms in stomach.
iii) Onion relives bronchial infections.

iv) Oats support convalescence.
v) Burdock herbals are helping in removing toxins from the body.
vi) Comfrey encourages blood clotting and help in healing the wounds fast.

It also plays an important role in the rural areas, particularly in remote places with fewer medicinal facilities.

It is estimated that about 70000 plant species are used for medicinal purposes. In Ayurveda about 2000 plant species are considered to have medicinal values, while, Chinese list over 5700 as traditional medicines. The Indian traditional medicine the Charak Samhita (1000 BC) records the use of over 340 drugs of vegetables origin.

Medicinal plants have curative properties due to the presence of various complex chemical substances of different composition, which are found as secondary plant metabolites in one or more parts of these plants. The plant metabolites are grouped as alkaloids, glycosides, cortico steroids, essential oils etc. Table 7.7 indicates name of some herbs useful to cure some diseases.

Table 7.7: Medicinal use of herbs

System/Disease	**Plant/Herbs**	**Uses**
Skin		
(a) Antiseptic	Tea tree (Melaleuca attemifolia)	Disinfect the skin
(b) Emollients	Marigold (Calendula officinalis)	Deduce itchiness, edness and soreness
(c) Healing	Comfrey (Symphytum offcinale)	Blood cotting, fast healing of wounds
Respiratory system		
(a) Antiseptic	Garlic (Allium sativum)	Helps the lungs resist infection
(b) Spas molytics	Visnaga (Ammi visnaga)	Relax bronchial muscles.
Urinary system		
(a) Antispectic	Buchu (Barosma betulina)	Disinfect the urinary tubules
(b) Astringents	Horsetail (Equisetum arvense)	Tightness & protect the urinary tubules
Musculo-skeletalsystem		
(a) Analgesics	Yellow Jasmine (Gelsemium sempervirens)	Relieve joints and nerve pain
(b) Antiinflammatories	White willow (Salixalba)	Reduce swelling and pain in joints
(c) Antispasmodics	Cinchona (cinchona spp.)	Relax tense and cramped muscles.
Nervous system		
(a) Relaxants	Lemon balm (Melissa officinalis)	Relax nervous system

(b) Sedatives	Mistletoe (Viscum album)	Reduce nervous activity
(c) Stimulants	Kolanut (Colaacuminata)	Increase nervous activity
(d) Tonics	Oats (Avena Sativa)	Improve nerve function and tone
Circulation and heart		
(a) Cardiotonics	Ddanshen (Salvia mittiorrhiza)	Improve the regularity and strength of the heart contractions
(b) Circulatory stimulants	Cayenne (Capsicum frutescens)	Improve circulations of the blood to the extremities.
(c) Diaphoretics	Juhua (Chrysanthemum × morifolium)	Promote sweating & lower blood pressure
(d) Spasmolytics	Cramp bark (Viburmum opulus)	Relax the muscelers & helps to lower blood pressure
Digestive organs		
(a) Antiseptics	Ginger (Zingiber officinalis)	Protect against infections
(b) Astringents	Bistort (Polygenum bistorta)	Tighten the inner line of intestines and provide protecting coating over them.
(c) Bitters	Wormwood (Artemisia absinthum)	Stimulate secretion of digestive juices
(d) Laxatives	Senna (assia senna)	Stimulate bowel movements
(e) Stomachs	Cardamom (Eletterio cardamomum)	Protect and support

Aromatic plants have been of great interest to mankind from the beginning of civilization. Aromatic plants and their products, particularly the essential oil, are now becoming one of the most important export items from many developing countries. The upswing trends basically is due to raising the standard of living of the people and technological advancement in the production and processing of these essential oils.

Essential oils are complex mixtures of odours and steam-volatile compounds which are deposited by plants in the sub-cuticular space of glandular hairs, in cell organelles (oil bodies of Hepaticae), in idioblasts, in excretory cavities and canals or exceptionally in heartwoods.

The main aromatic plants are mint (mentha oil), cymbopogons. turpentine, sandal wood, vetiver, eucalyptus and ocimum. The other aromatic plants are celery, jasmine, rose, dill, geranium, hops, cinamomum, cedar wood, cyperus etc.

7.4.2 Processing of Medicinal and Aromatic Plants

The unit operations involving processing of plants based medicinal or aromatic constituents are:

1. **Comminution:** It is the process of size reduction. So that the surface area of the produce increases and solvent can easily interact with the produce. Most of the natural produce is to be dried. Drying can be done in sun or shade or in the protected area depending upon the type of the constituents. It is preferred that drying should be slow at low temperature. The dried material is to be crushed or broken into small parts before extraction/ distillation. During crushing/grinding temperature of the produce should not be increased. Some of the volatiles get evaporated even at 45^oC. The homogeneity of the ground particle shows the efficacy of the extraction of active ingredient

2. **Extraction of active ingredient:** Extraction is the process of separation of the active constituents from the plant material using a solvent. Firstly plant produce is pre-treated with the solvent outside the extractor. It facilitates the breaking of the cell walls to release the extractable component. The rate at which the solvent reacts with the solute depends upon solute solvent ratio, pH, particle size and temperature. Alcohol is the widely used solvent. It has the ability to extract many soluble constituents. Most of the alkaloids are soluble in acids.

For extraction of essential oil, steam distillation process in widely used. In this the steam is produced and passed through the bed of plant material. The steam carries the volatiles, which generally boils at a temperature lower than steam. It condenses and most of essential oils are insoluble in water. They are separated in the aqueous phase, forming two layers, then they can be easily separated. The factors, which influence the quality and quantity of extraction, are; size of load, steam pressure, density of packing of planting material in the bed, duration of distillation and rate of steam injection.

The aroma constituents are heat sensitive. So the technique must be carried out with pure and low boiling solvents such as pentane or hexane. Extraction with super critical solvents generally carbon-di-oxide is the most effective but capital intensive.

Check Your Progress Exercise 5 ✍

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Why herbal-based medicines are suitable to the human body?

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2. What is the need of comminution in the medicinal and aromatic plants?

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3. Efficacy of extraction mainly depends upon ………………………………

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7.5 LET US SUM UP

The knowledge of commercial crops, spices and medicinal and aromatic plants is necessary. It provides ample employment opportunity. India is known for its knowledge in their cultivation and quality processing since ages. Indians were deployed to other countries to teach cultivation of sugarcane. The merchants traded Indian spices many centuries ago. The ancient herbal medicines suits human bodies as they do not have any side effect.

The production, processing of each of the crop is different. The process technology depends up on the active constituent which is to be extracted. Its purity decides the price.

7.6 KEY WORDS

Molasses : A by-product of sugarcane industry and base material for distillery and fermented products.

H.S.C. : Highest Standard Count (HSC) is a unit to express and evaluate quality of the cotton.

Pungent principal : The main constituent responsible for pungency. For i.e. pepper it is alkaloid piperine.

T.KP. : Tamarind Kernel Powder (TKP) is the powder of dried tamarind kernel seeds. It is used as material in textile industry.

Essential oils : It is a complex mixture of odours and steam-volatile compounds, which are deposited by plants in the sub-cuticular space of glandular hairs, in cell organelles or in canals of woods.

Comminution : It is the process of size reduction of any substances so that surface area is increased.

Steam distillation : It is the process of boiling the substances with water, so that water soluble volatiles oils are carried away by the steam. Then steam is to be condensed so that oils being lighter can be easily separated.

7.7 ANSWER TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Sugarcane plant harnesses solar energy and converts it into sugar, cellulosic and non-cellulosic energy producing substances. So it is called as energy efficient crop.
2. It provides huge employment, produces lint as well as oil seed.
3. About 100 kg sugar
4. To avoid inversion of sugar.
5. It is diuretic, refreshing and cooling.
6. Digestion, washing, screening, bleaching, dewatering and thickening are the unit operations in paper manufacturing.

Check Your Progress Exercise 2

1. Fineness, maturity and strength are the indices to judge quality of cotton.
2. 27 mm and above
3. i) India ii) Cardamom iii) Pepper

Check Your Progress Exercise 3

1. Sun
2. 24-36 hours
3. Alkaloid piperine
4. Papaya seed

Check Your Progress Exercise 4

1. To check internal bleeding of piles.
2. Tartaric acid.
3. It is due to Millard reaction. It can be prevented by storing in airtight container at cool and dry place.
4. Tamarind kernel powder (TKP) is used in the textile industry.
5. It clears the pimples and unwanted hairs.

Check Your Progress Exercise 5

1. Herbal based medicines work in concert with the body's own defense system.
2. It increases the surface area so that solvent can easily interact with the active constitute.
3. Homogeneity of the product after comminution.

7.8 SOME USEFUL BOOKS

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UNIT 10 LOSS OF FOOD VALUE IN FRESH PRODUCE AND PROCESSED PRODUCTS

Structure

10.0 OBJECTIVES

After reading this unit, you should be able to:

- describe the protection and preservation techniques;
- explain biochemical changes after harvesting and slaughter; and
- discuss the handling, transport and safe storage of fruits and vegetables.

10.1 INTRODUCTION

Fruits and vegetables are highly perishable commodities. These are affected by a number of factors leading to post harvest spoilage and hence, post harvest losses are the major source of food loss. Besides, packaging, transportation, and marketing of these perishables also contribute to post harvest losses. These are passed through a long channel before their use, which may lead to a number of undesirable physico-chemical changes in their composition. The losses may take place further, if the produce is not processed following the scientific methodology. In order to reduce the losses and maintain the quality to a maximum extent, effective post harvest management of fruits and vegetables during handling, transportation, marketing, and storage of fresh and processed products is of great importance.

10.2 ASSESSMENT OF LOSS

Fruits and vegetables respire even after harvesting and undergo biochemical changes. Their condition and marketable life are affected by temperature, humidity, composition of the atmosphere which surrounds them, level of damage that has been inflicted on them before, during and after harvest, and the type and degree of infection with microorganisms, insects etc. Fruits and vegetables will deteriorate during storage through loss of moisture, loss of nutrients, physical loss through pest and disease attack, loss in quality from physiological disorders, fibre development, greening (potatoes), shoot growth, seed germination etc.

Various loss assessment methods have been used in practice for perishable commodities. In a study of apples arriving at a central market in Mexico over a period of one year, various measurements were made using European Community (EC) Standards (Table 10.1).

Table 10.1: Quality standards and losses of apples at wholesale market level in Mexico

Quality rating	Reasons for being unmarketable	Percentage
Extra		0.2
1		11.0
2		29.6
3		25.7
Below 3		15.5
Unmarketable		18.0
	Physiological (dehydration, over-maturity, physiological disorders)	9.0
	Fungal diseases (Penicillium, Gloeosporium, Phytophthora)	10.0
	Insect infestation	2.1
	Bitterpit	1.4
	Freezing injury	0.2
	Mechanical damage	6.8

Source: Noon R.A. (1979). Report on an assignment as Plant Pathologist to CONAFRUTA, Mexico City, March 1977-September 1979. Tropical products Institute Report R923, 34 pp.

The factors in the life cycle of fresh fruits and vegetables, which can influence their post-harvest losses, are crop production factors (temperature, nutritional status, light, day length, chemical treatments, infections or infestations etc.), maturity level at harvesting, method of (manual or mechanical) harvesting, removing crops from the field, treatments (pesticides, heat, sprout suppressants, curing), storage and transport conditions, packaging, type of transport, type of store, temperature (pre-cooling, store temperature), humidity, and atmospheric gases.

Losses occur at different times during the production and post harvest cycle of crops, and have a variety of causes. If it is clear that the losses are due to infections caused by microorganisms the control measures will depend on the type of microorganism, the time of infection, the reason for the success of infection and permissible control measures. It follows that effective and sustainable control of post harvest losses should be an integrated approach taking into account health, economics and practicality of the situation. It is important to know the time in marketing chain when losses occur. Losses are usually higher when the crop enters the marketing chain (particularly during wholesale marketing) than in crops consumed by the producer.

10.3 FACTORS CAUSING SPOILAGE: PHYSICAL, PHYSIOLOGICAL, THERMAL, MICROBIAL, CHEMICAL, INSECTS, PESTS, DISEASES

Factors causing spoilage often do not operate in isolation. At one time, many forms of deterioration may take place, depending on the type of food and the environmental conditions that its exposed to.

Physical Factors

Storage conditions like temperature, oxygen, light, duration of storage etc are the important factors that influence the type of microbial growth and spoilage.

The rate of a chemical reaction doubles itself for every 10^0 C rise in temperature. Excessive heat brings about protein denaturation and destruction of vitamins. Several fruits and vegetables deteriorate even at refrigeration temperature (4^0 C) resulting in disclouration, changes in texture etc. Freezing may also cause deterioration of liquid foods e.g. separation of fat particles from a food emulsion.

Atmospheric oxygen brings about undesirable changes in foods such as discolouration, flavour changes and loss of vitamin A and C. Light destroys riboflavin, vitamin A and C and also many food colours. All the other food deterioration factors are time-dependent. The longer the storage time, greater the deterioration of food.

Physiological Factors

Rate at which the stored product respires is a major factor in determining the pace of physiological ageing. Deterioration in fruits and vegetables occurs mainly through the process of physiological ageing and water loss.

The characteristics of a food influence the type of microorganisms that can grow in it and thus determine the changes in its appearance, flavour and other qualities. Proteins are degraded by proteolytic organisms. Fats are digested by relatively few microorganisms, mainly moulds. Fats become rancid due to hydrolytic decomposition to mal-odourous fatty acids. Carbohydrates are affected by carbohydrates fermenting microorganisms; particularly yeasts and moulds.

Moisture is required both for chemical reactions and microbial growth. Foods with a high percentage of moisture deteriorate fast. Variation in surface moisture due to change in relative humidity can lead to lumping and caking, surface defects, crystallization and stickiness in foods. Condensation of even small amounts of moisture can result in multiplication of bacteria.

Acidity- Due to low pH, most of fruits are mainly spoiled by yeasts and moulds. Nonacid foods (vegetables, meat, fish, milk) are particularly subject to bacterial spoilage, but also support growth of moulds under favourable conditions.

Thermal Factors

Inappropriate temperature during food processing and storage are one of the main causes of food deterioration. At high processing temperature proteins get denatured and browning takes place (Maillard reaction). Water soluble vitamins particularly vitamin C, thiamine and riboflavin are heat sensitive and destroyed at high temperatures. Oxidative rancidity is accelerated by heat, metallic tins and light. The rate of oxidation of fat is doubled for each degree increase in temperature. Sugars and starches are degraded by prolonged heating at high temperature.

Microbial Factors

Bacteria, yeasts and moulds often cause food spoilage after harvesting, during handling, processing and storage. They attack all the food components – sugar, starche, cellulose, fat and protein. Depending on the food and the microorganisms, the action on food could be to produce acids, making the food sour, or produce alcohol. Some microorganisms produce gases, making the food foamy; still others produce unwanted pigments or toxins.

Chemical Factors

Pesticides can leave residues on plant produce much more than safe limits and make them unfit for consumption. Poisonous chemicals may enter foods from utensils, e.g., from cadmium plated ware or cheap enamelled ware containing antimony. Lead and arsenic residues from fruit sprays may be on fruit surface, but usually in harmless amounts, especially after washing. Indiscriminate use of all plastic packaging material like polyvinyl and polyethylene material can be a health hazard, e.g., it may lead to the reaction of acid and oil of pickles with plastic packaging as observed in some cases.

Insects, Pests, Diseases

Insects, worms, bugs and fruit flies may damage foodstuffs such as grains, fruits and vegetables and render them unfit for consumption. Apart from losses due to food eaten, insects cause greater damage due to bruises and cuts they make in foods exposing them to microbial attack resulting in total decay. Pests such as rodents introduce high degree of filth in form of excreta, bodily secretions and spoilage microorganisms. For example, rats can transfer the bacteria S*almonella* to the food, may cause salmonellosis.

Several types of pathogenic fungi are able to initiate an infection on the surface of floral parts and on, developing fruits. Many fungi that cause considerable wastage of produce are unable to penetrate intact skin of the produce, but readily invade broken skin. In addition, the cut stem is a frequent point of entry for microorganisms, and stem-end rots are important forms of post harvest wastage of many fruits and vegetables.

Table 10.2: Major post harvest diseases of some fresh fruits and vegetables

Crop	Disease	Pathogens
Apple, pear	Lenticel rot Blue mold rot	*Phlyctaena vagabunda* *Penicillium expansum*
Banana	Crown rot Anthracnose	*Colletotrichum musae Arx, Fusarium roseum, Verticillium theobromae, Ceratocystis paradoxa* *Colletotrichum musae*
Citrus fruits	Stem end rot Green mould rot Blue mould rot Sour rot	*Phomopsis citri Faw, Diplodia natalensis, Alternaria citri* *Penicillium digitatum Sacc.* *Penicillium italicum Wehmer* *Geotrichum candidum*
Papaya, mango	Anthracnose	*Colletotrichum gloeosporiodes*
Pineapple	Black rot	*Ceratocystis paradoxa,*
Potato, leafy vegetable	Bacterial soft rot Dry rot	*Erwinia carotovora* *Fusarium species*
Leafy vegetables, carrot	Watery soft rot	*Sclerotinia sclerotiorum*

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What do you understand by spoilage?

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2. What are different factors that can deteriorate the quality of fresh and processed products? Explain in brief.

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3. How the pests can make the food unfit for consumption?

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10.4 POST-HARVEST/ SLAUGHTER – BIOCHEMICAL CHANGES

10.4.1 Post-Harvest Biochemical Changes

The perishable foods like fruits and vegetables continue to undergo chemical changes even after harvest. The changes of fruits after harvest are numerous. Some of the very important changes include changes in (i) rate of respiration, (ii) water content, (iii) carbohydrates and (iv) organic acids and pH.

i) A major metabolic process which takes place in harvested produce or in any living plant is respiration. Respiration rate per unit weight is highest for the immature fruits or vegetables and then steadily declines with the age.

ii) When fruit and vegetables are picked from the plants, water no longer flows into the foods although the loss continues. In dry atmosphere and at high temperatures, water loss is rapid. For e.g., apples rapidly cooled after delivery to the storage area have a much smaller water loss than those cooled slowly. During the ripening period of bananas, the water content in the pulp increases and in the peel decreases. Water loss in bananas (and probably in other fruits) is checked by waxy layer of the skin.

iii) Many changes occur in the carbohydrate fraction of fruits during ripening. This alters both taste and texture of the produce. The green fruits usually contain an abundance of starch, but are short on the soluble sugars that give ripe fruit its sweetness. On ripening, however, starches decrease and sugars increase in concentration.

One of the most obvious changes in fruit is the alteration in texture. The breakdown of polymeric carbohydrates, especially pectic substances and hemicelluloses, weakens cell walls and the cohesive forces binding cells together. In the initial stages, the texture becomes more palatable, but eventually the plant structures disintegrate. Protopectin is the insoluble parent form of pectic substances. During ripening and maturation, protopectin is gradually broken down to soluble pectin. The rate of degradation of pectic substances is directly correlated with the rate of softening of fruit. For e.g. pears are picked in the hard stage and held at low temperatures until required for ripening. On return to room temperature they rapidly ripen and soften due to increase in soluble pectin. Fruits like banana, peaches, plums and tomatoes also show loss of protopectin and rise in soluble pectins on ripening.

10.4.2 Post-Slaughter Biochemical Changes

There are a series of biochemical changes occurring after slaughter. When an animal dies, the skeletal muscles stiffen in rigor mortis and remain in this condition for a period after which they soften and become flexible again. The onset of rigor is quickened by high temperatures and delayed by low temperature. Rigor mortis is important in meat products since muscles cooked while still in rigor are much tougher than if it is allowed to soften before cooking. The stiffness, that develops when muscles pass into rigor, is the result of changes in the proteins. Living muscle fibres contain protein in a soft, pliable gel. During rigor this gel stiffens, but when rigor passes, the muscle again becomes soft and pliable. After the passing of rigor mortis, meat becomes progressively more tender, juicier, and more flavourful. The speed with which this ripening or aging occurs, depends on the time and temperature of keeping the carcass. Changes occur quite rapidly at room temperature but more slowly at refrigerator temperatures.

10.5 HANDLING AND TRANSPORT

Fruits and vegetables continue to respire even after harvesting. We cannot improve the quality of the harvested commodities but it can be retained till consumption if the rate of metabolic activities is reduced by adopting the appropriate post harvest handling operations (Fig. 10.1).

Pre-cooling

Pre-cooling (prompt cooling after harvest) is important for most of fruits and vegetables because they may deteriorate as much in 1 hour at 32^0C as they do in 1 day at 10^0C or in 1 week at 0^0C. In addition to removal of field heat from commodities, pre-cooling also reduces bruise damage from vibration during transit. Cooling requirement for a crop vary with the air temperature during harvesting, stage of maturity, and nature of crop. Different methods of cooling are given commodity-wise in Table 10.3.

Table 10.3: Commodity-wise cooling methods

Cooling method	Commodity
Room cooling	All fruits and vegetables.
Forced air cooling (pressure cooling)	Fruits and fruit type vegetables, tubers and cauliflower.
Hydro cooling	Stem, leafy vegetable, some fruits and fruit type vegetables.
Package icing	Roots, stem, some flower type vegetables, green onions and brussel sprouts.
Vaccum cooling	Some stem, leaf and flower type vegetables.
Transit cooling	
Mechanical refrigeration	All fruits and vegetables
Top icing and channel icing	Some roots, stems, leafy vegetables

Washing, Cleaning and Trimming

Before fresh fruits and vegetables are marketed various amounts of cleaning are necessary which typically involves the removal of soil, dust, adhering debris, insects and spray residues. Chlorine in fresh water is often used as disinfectant to wash the commodity. Some fungicides like Diphenylamine (0.1-0.25%) or ethoxyquin (0.2-0.5%) may be used as post-harvest dip to control an important disorder of apple known as superficial scald. Many vegetables need trimming, cutting and removal of unsightly leaves or other vegetables parts.

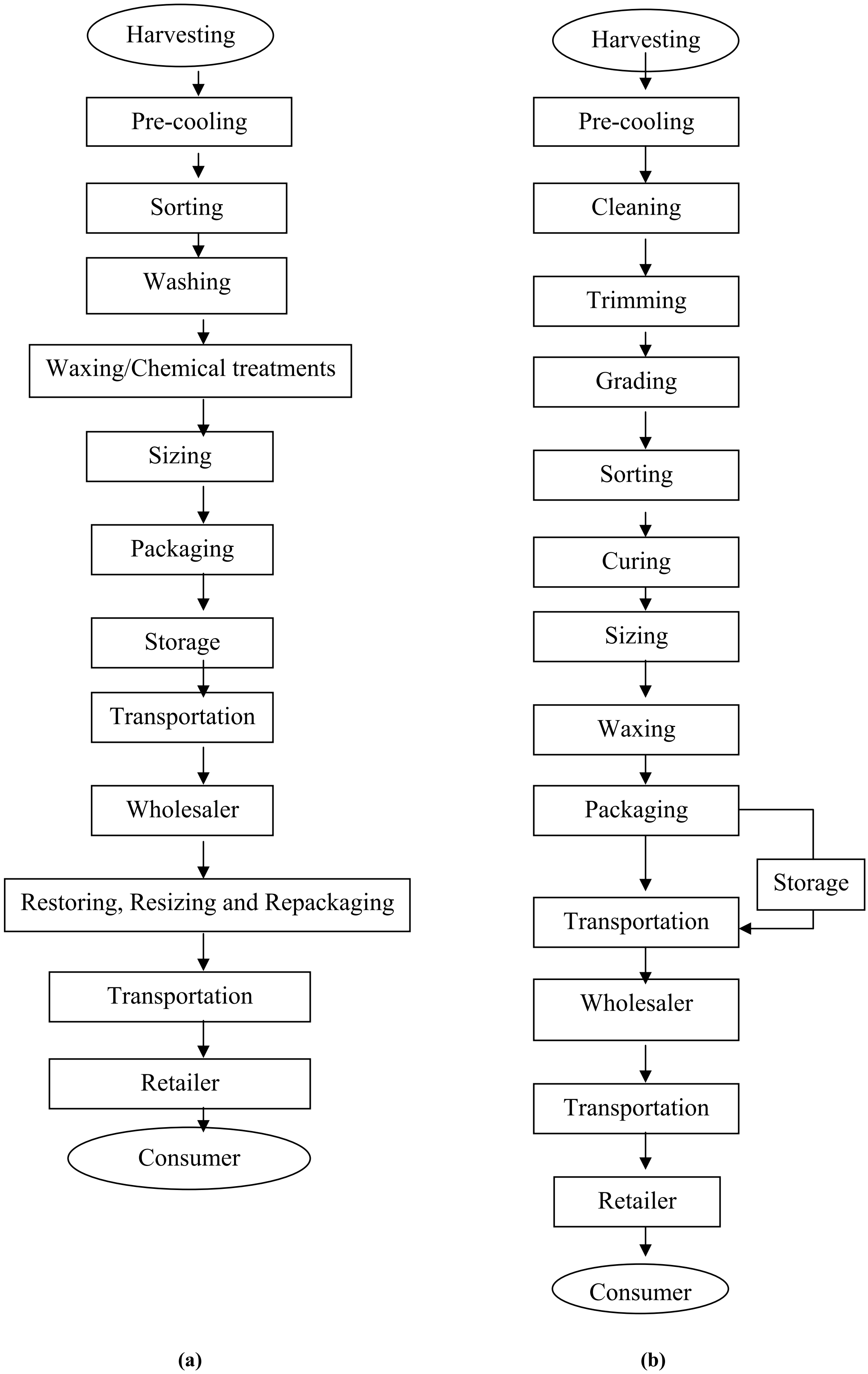

Figure 10.1: Post-harvest handling operations of a) fruits, and b) vegetables

Sorting, Grading and Sizing

Sorting is done by hand to remove the fruits, which are unsuitable to market or store due to damage by insects, diseases or mechanical injuries. The remainder crop products are separated into two or more grades on the basis of the surface colour, shape or visible defects. For example, in an apple packing house in India 3 grades viz. extra fancy, fancy and standard may be packed for marketing. After sorting and grading, sizing is done either by hand or machine. Sizing on the basis of fruit shape and size are most effective for spherical (oranges, tomato, certain apple cultivars) and elongated (delicious apples, European pears or of non-uniform shaped commodities, respectively. Grading-packing line machines with facilities of washing, waxing and drying in addition to sizing are now days available in the market.

Curing

Curing is an effective operation to reduce the water loss during storage from hardy vegetables viz. onion, garlic, and other root vegetables. The curing methods employed for root crops are entirely different than that from the bulbous crops (onion and garlic). The curing of root and tuber crops develops periderm over cut, broken or skinned surfaces for wound restoration. It helps in the healing of harvest injuries, reduces loss of water and prevents the infection by decay and attack by pathogens. Onion and garlic are cured to dry the necks and outer scales. For the curing of onion and garlic, the bulbs are left in the field after harvesting under shade for a few days until the green tops; outer skin and roots are fully dried.

Waxing

Waxing generally reduces the respiration and transpiration rates, but other chemicals such as fungicides, growth regulators, preservative can also be incorporated specially for reducing microbial spoilage, sprout inhibition etc. However, it should be remembered that waxing does not improve the quality of any inferior horticulture product but it can be a beneficial adjunct to good handling. Some of the commonly used waxes are paraffin wax, carnauba wax, bees wax, wood resins, shellac, etc.

The majority of quality contributing factors as affected by wax application includes reduction in the physiological loss in weight (PLW), delay in respiration rate, reduction in post-harvest spoilage and maintenance of improved quality of commodity intended for storage to increase the shelf life. The principal disadvantage of wax coating is the development of off flavour if not applied properly. Adverse flavour changes have been attributed to O_2 and CO_2 exchange, thus resulting in anaerobic respiration and elevated ethanol and acetaldehyde contents.

Packaging

Proper or scientific packaging of fresh fruits and vegetables reduces the wastage of commodities by protecting them from mechanical damage, pilferage, dirt, moisture loss and other undesirable physiological changes and pathological deterioration during the course of storage, transportation and subsequent marketing. For providing uniform quality to packed produce, the commodity should be carefully supervised and sorted prior to packaging. Packaging cannot improve the quality but it certainly helps in maintaining it as it protects the produce against the hazards of transportation.

Transportation

Mechanical damage to packages occurs particularly during handling and transportation. Rail, road, sea and air transport may all be used to move produce to its destination. Air-transport relies on short journey time to maintain produce quality. The packaging requirement during surface transport are generally greater than by air owing to longer time taken for the journey, higher humidity and usually greater stack heights. The use of pallets and mechanical aids can reduce handling damage to the package considerably. It is very important that the package maintains its integrity throughout the journey.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Explain briefly the important changes take place in harvested fruits and vegetables.

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2. Why pre-cooling is important for harvested fruits and vegetables?

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3. Discuss the unit operations, which are important for handling of fruits and vegetables.

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10.6 COLD STORAGE

Fresh produce changes in quality and quantity between harvest and consumption. These losses have been observed to the tune of 20-50 per cent particularly in developing country depending upon the commodity. Fresh produce like fruits and vegetables and ornamentals are living tissues, which are subjected to continuous change after harvest due to inadequate handling, packaging, transport and storage. Deterioration in fruits and vegetables occur mainly through the process of physiological ageing and water loss. The rate at which the stored product respires is a major factor in determining the pace of physiological ageing.

The deterioration in the agricultural produce of high value (milk, meat, fish, fruits, and vegetables) depends largely on storage temperature. One way to minimize deterioration reduce losses consists of lowering their storage temperature to an appropriate level. The storage of foods for extended periods at lowered temperatures is called as cold storage.

Refrigeration or Chilling

Chilling temperatures are obtained by means of ice or mechanical refrigeration. Fruits, vegetables and their products and other high value foods can be stored for a few days to many weeks when kept at chilling temperature. It is necessary to refrigerate fruits and vegetables as soon as they are harvested, fish as soon as they are caught and meat as soon as slaughter has taken place under good hygienic conditions, eggs recently laid, etc. to maintain the quality of the foods. It is important to cool the produce before refrigeration, maintain RH conditions for the food, and carry out renewal of air.

Freezing

Freezing method is most harmless method of storage of food for longer duration. At temperature below the freezing point of water (-18^0 to -40^0 C) growth of microorganisms and enzyme activity are reduced to a minimum. Most perishable foods can be preserved for several months if the temperature is brought down quickly (quick freezing) and the food is kept at these temperatures. Quick frozen foods maintain their quality and freshness when they are thawed because only very small ice crystals are formed when foods are frozen in this manner.

Table 10.4: Practical storage life of some frozen products

Product	**Practical storage Life (in months)**		
	-18^0C	**-25^0C**	**-30^0C**
Fruits			
Peaches, apricots or cherries (sweet or sour) in sugar	12	18	24
Raspberries or strawberries in sugar	18	<24	>24
Citrus or other fruit concentrates	24	>24	>24
Vegetables			
Broccoli	15	24	>24
Carrots	18	>24	>24
Cauliflower	15	24	>24
Peas	18	>24	>24

Raw meat and meat products			
Beef carcass	12	18	24
Veal carcass	9	12	24
Pork carcass	6	12	15
Poultry, chicken and turkeys eviscerated (packaged) Fried chicken	12 6	24 9	24 12
Whole eggs, liquid	12	24	>24
Marine products			
Fatty fish	4	8	12
Lean fish	8	18	24
Milk products			
Butter from pasteurized and matured cream	8	12	15
Cream	6	12	18
Ice-cream	6	12	18
Bakery and confectionery			
Cakes-cheese, sponge, chocolate, fruit, etc	12	24	>24

10.7 PROTECTION AND PRESERVATION TECHNIQUES

Foods are perishable and hence cannot be stored at ordinary temperatures for any length of time. So there comes the need of protection and preservation. It becomes necessary to take the preventive measures to increase the shelf life, or to treat these commodities with some life enhancer or processing them to various products. In the preservation of food, the following methods are involved:

I. Prevention or delay of microbial decomposition

  a) by keeping out microorganisms (asepsis- packaging prevents entry of microorganisms in food, e.g. canned peas);

  b) by removal of microorganisms, e.g. filtration;

  c) by hindering the growth and activity of microorganisms, e.g., by low temperature, drying, anaerobic conditions, chemicals or antibiotics; and

II. By killing the microorganisms, e.g., by heat or irradiation.

III. Prevention or delay of self-decomposition of food

  a) by destruction or inactivation of enzymes, e.g., by blanching or boiling;

  b) by prevention or delay of chemical reactions, e.g., prevention of oxidation by means of an antioxidant.

IV. Prevention of damage by insects, animals, mechanical causes, etc.

Various methods generally used for preservation of foods are as under:

I. Preservation by High Temperature: Two common methods of preservation by high temperatures are preservation are usually: pasteurization and sterilization.

a) Pasteurization

Pasteurization destroys pathogenic microorganisms and extends shelf life of the product by decreasing the microbial population and inactivation of enzymes, for example, pasteurized milk and other dairy products, beer, fruit juices and aerated drinks. Dried fruits like raisins, apricots and dates can also be pasteurized in the package.

b) Sterilization

Sterilization means the destruction of all viable microorganisms. The time and temperature necessary for sterilization vary with the type of food. Vegetables like green peas, beans, okra etc being non acidic contains more starch than sugar, require higher temperature to kill the spore forming organisms. Continuous heating or 30 to 90 minutes at 116^0 C is essential for their sterilization. Temperature above 100^0 C can only be obtained by using steam pressure sterilizers such as autoclaves.

Aseptic Canning

Aseptic Canning is a technique in which food is sterilized outside the can and then aseptically placed in previously sterilized cans, which are subsequently sealed in an aseptic environment, e.g., fluid and semi fluid products. The temperature employed may be as high as 149^0 C and sterilization takes place in 1 or 2 seconds.

Hot Pack or Hot Fill

Hot pack refers to the filling of previously pasteurized or sterilized food while still hot, into clean but not necessarily sterile containers under clean but not necessarily aseptic conditions, e.g. filling of hot jams in jars. Heat of the product and some holding time before cooling render the container sterile.

II. Preservation by Low Temperature

Microbial growth and enzymatic recitations are retarded in foods stored at low temperatures. Low temperatures can be obtained by (a) refrigeration or chilling (0-5^0C) suitable for storage of potatoes, apples and other perishables, and (b) freezing (-18 to -40^0 C) suitable for storage of most of the perishables.

III. Preservation by Chemicals

Certain chemicals when added in small quantities can hinder undesirable chemical reaction in food by interfering with cell membrane and enzymatic activity of microorganisms or their genetic mechanisms and acting as antioxidants. Benzoic acid, potassium metabisulphite, sorbic acid, calcium propionate are some of the chemicals used as preservative.

The development of off flavours (rancidity) in edible oils is prevented by the use of butylated hydroxy anisole (BHA), butylated hydroxy toluene (BHT) or lecithin, which act as antioxidants.

IV. Preservation by drying

When the moisture content of food is brought down below a certain level, microorganisms are unable to grow. Moisture can be removed by heat application as in sun drying or by mechanical drying (dehydration), e.g. dried green peas, cauliflower and raw mango, and fruit juice powder, etc.

V. Preservation by filtration

In this method, the juices are clarified by settling or by using ordinary filters and then passed through special filters, which are capable for retaining yeasts and bacteria. Various types of germ proof filters are used for this purpose.

VI. Preservation by Carbonation

Carbonation adds to the life of a beverage and contributes in some measures to its tang. Another advantage of carbonation is the removal of air thus creating an anaerobic condition, which reduces the oxidation of ascorbic acid and prevents browning.

VII. Preservation by Salt or Sugar

Salt at a concentration of 15 to 25 per cent is sufficient to preserve most products by: (i) causing high osmotic pressure resulting in the plasmolysis of microbial cells, (ii) dehydrating food as well as microorganisms by drawing out and tying up the moisture (iii) ionizing to yield the chloride ion which is harmful to microorganisms, (iv) reducing the solubility of oxygen in water, sensitizing the cells against carbon dioxide, and interfering with the action of proteolytic enzymes. Sugar absorbs most of the available water resulting very little water for microbial growth hence their multiplication is inhibited and even those already present die out gradually. Thus sugar acts as preservative by osmosis as in case of jam, jelly, candy, marmalade, etc.

VIII. Preservation by Fermentation

Decomposition of carbohydrates by microorganisms or enzymes is called 'fermentation'. By this method, foods are preserved by the alcohol or organic acid formed by microbial action. The keeping quality of the alcoholic beverages (wine, beers), vinegar and fermented pickles depends upon the presence of alcohol, acetic acid and lactic acid, respectively. About 2 per cent acetic acid prevents spoilage in many products.

IX. Preservation by Acids

Acidic conditions inhibit the growth of many microorganisms hence organic acids are added to or allowed to form in foods to preserve them. Acetic acid in pickles, citric acid in squashes, jam and jellies, lactic acid are commonly used for preservation.

X. Preservation by oil and spices

A layer of oil on the surface of any food produces anaerobic conditions, which prevents the growth of moulds and yeasts. Thus pickles in which enough oil is added to form a layer at the top can be preserved for long periods. Spices like turmeric, pepper, and asafoetida have very little bacteriostatic effect but their primary function is to impart their characteristic flavour to food.

XI. Preservation by Antibiotics

Certain metabolic products of microorganisms have been found to have germicidal effect and are termed as antibiotics. Nisin, an antibiotic used in canning of mushrooms, tomatoes and milk products. Subtilin is used for the preservation of asparagus, corn, and peas. *Pimaricin* can be used for treating fruits and fruit juices. At present these three antibiotics are permitted only in such foods. Residual antibiotics are expected to be destroyed during cooking as these foods are expected to cook prior to consumption.

XII. Preservation by irradiation

The ionizing radiations (gamma rays or electro beams) can be used for sterilization of foods in hermetically sealed packs, reducing the spoilage flora on perishable foods, elimination of pathogens in foods, control of infestation in stored cereals, prevention of sprouting of potatoes, onion etc. The irradiation of food can be considered to a method of 'cold sterilization', i.e. food is free of microorganisms without high temperature treatment. This method has not yet gained general acceptance due to the unacceptable flavour of some irradiated food and fear of hazard.

10.8 EVAPORATIVE COOLING AND STORAGE

Temperature and moisture content are two most important parameters, which control the rate of decay of food commodities during storage. The higher the temperature the more is the rate of respiration and other biochemical processes, and the food is more likely to develop abnormalities with resultant loss of quality and nutritive value. The vital activities of the tissues such as transpiration, respiration and ripening etc. continue even after harvest. The high moisture content of the horticultural commodities accelerates these reactions making them highly perishable. Very low humidity in the storage space causes undesirable moisture loss from the commodity leading to desiccation and shrivelling. Thus, the principal aim of storage in fresh form is to control wilting and shrinkage alongwith the above undesirable physiological and biochemical changes and infections. This can be achieved by maintaining lower temperature and high humidity conditions through evaporative cooling.

Evaporative cooling is the adiabatic saturation of moist air. It is a thermodynamic process, where a part or all of the sensible heat of moist air is converted to latent heat, thereby, producing a reduction in temperature. Evaporation of water produces a considerable cooling effect and the effect increases with increase in the amount of evaporation. Theoretically, the lowest temperature that can be achieved by the evaporation of water is the wet bulb temperature of the moist air. Evaporative cooling has been extensively utilized for creating a modified atmosphere in an enclosure for crop growing, livestock housing or storage of horticultural produce. Evaporative cooling has also been recommended for removal of field heat from produce on the farm and for short duration storage after it is removed from the cold stores before distribution.

Evaporative cool chambers maintain 10-15^{0} C lower temperature compared to field temperature, depending on the season and also maintain around 90 per cent relative humidity. The fruits and vegetables can be stored in plastic crates in the chamber. The shelf life of some fruit and vegetables in the cool chambers have been observed to increase from 3 to 90 days as compared to storage at room temperature.

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.

b) Compare your answers with those given at the end of the unit.

1. What are different principles of food preservation? List out with examples.

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2. How the temperature effect the storage of fruits and vegetables, explain in brief.

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10.9 LET US SUM UP

Fruits and vegetables are highly perishable commodities. Fresh produce changes in quality and quantity between harvest and consumption. These changes depend upon a number of factors. The quantitative losses have been observed to the tune of 20-50 per cent mainly because of inappropriate handling, packaging, transport and storage of the fresh produce. Deteriorative changes in fruits and vegetables occur mainly due to the action of microorganisms, storage conditions like temperature, oxygen, light, duration of storage, characteristics of the food, insects, pest, diseases etc.

Post harvest handling is one of the major factors that affect the overall quality and losses during transport and marketing. Spoilage in fruits and vegetables depends largely on storage temperature. Deteriorative changes and quantitative losses can be reduced significantly by lowering the storage temperature to an appropriate level. The storage of foods for extended periods at lowered temperatures is called as cold storage.

Most of the fruits and vegetables cannot be stored for too long. So there arises the need of protection and preservation. Fruits and vegetables can be preserved by high temperatures (as in case of pasteurization, sterilization, canning), low temperature (refrigeration or freezing), preservatives, removal of moisture, use of salt, sugar, acids, oils, antibiotics, and irradiation.

10.10 KEY WORDS

Canning : the process of preserving food by sterilization at $>100^0$ C and cooking in a sealed metal can, which destroys bacteria and protects from contamination.

Carbonation : is the process of dissolving sufficient carbon dioxide in water or beverage so that the product when served gives off the gas as fine bubbles and has a characteristic taste, e.g. carbonated fruit beverages.

Maillard reaction : the reaction between lysine (an amino acid in protein) and sugars is known as Maillard reaction. This deteriorative change takes place on heating or prolonged storage.

Pasteurization : when food is heated in containers or by other method to a temperature below 100^0 C for a definite period of time, the process is known as pasteurization.

Respiration : oxidative breakdown of complex materials, present in cells, such as carbon dioxide and water, with the production of energy and other molecules that can be used by the cell for synthetic reactions.

Spoilage : is a condition produced by excessive growth of microorganisms leading gradually to decay or decomposition or by other physical and chemical causes.

10.11 ANSWER TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

Your answer should include the following points:

1. Undesirable changes in foods.

   Food spoiled due to action of microorganisms, insects, pests, enzymes and other factors. See sub-sec. 10.3.

2. Physical factor, physiological factors, thermal factors, microbial factors, chemical factors, insects, pests, diseases. See Sub-sec 10.3.
3. Rodents contaminate the food with their urine and droppings.

   Rats can contaminate the food with microorganisms. See Sub-sec 10.3.

Check Your Progress Exercise 2

Your answer should include the following points:

1. Respiration.

   Changes in water content.

   Organic acids and starch content decreases. Sugar content increases.

   See sub-sec 10.4.1.
2. Reduces field heat.

   Reduces the rate of deterioration. See sub-sec 10.4.
3. Pre-cooling, washing, cleaning, trimming, sorting, grading, curing, sizing, waxing, packaging. See sub-sec 10.4.

Check Your Progress Exercise 3

Your answer should include the following points:

1. Prevention or delay of microbial decomposition

   By killing the microorganisms.

   Prevention or delay of self-decomposition of food. See sub-sec. 10.7.
2. High temperature enhances decay.

   Low temperature reduces losses and enhances shelf life. See sub-sec. 10.7 and 10.8.

10.12 SOME USEFUL BOOKS

1. Srivastava, R.P. and Kumar Sanjeev (2002) Fruit & Vegetable Preservation (Principal and Practices 3rd Revised and Enlarged Edition), International Book Distributing Co.
2. Thompson, A.K. (1996) Post Harvest Technology of Fruit and Vegetables, Blackwell Science Ltd., London.
3. Wills, R., McGlasson, B., Graham, D. and Joyce, D. (1998) Post-harvest an Introduction to the Physiology and Handling of Fruit, Vegetables & Ornamentals, CAB International, Australia.
4. Wills, R.B.H., McGlasson, Graham D., Lee, T.H. and Hall, E.G. (1989) Post Harvest an Introduction to the Physiology and Handling of Fruit and Vegetables. CBS Publishers and Distributors, Delhi.

UNIT 11 ANTI-NUTRITIONAL FACTORS, FOOD CONTAMINANTS AND TOXIC ELEMENTS

Structure

11.0 OBJECTIVES

After reading this unit, you should be able to:

- describe food contamination, factors contributing contamination and methods of prevention;
- list the anti-nutritional factors in food;
- discuss food born illness; and
- state deficiency diseases.

11.1 INTRODUCTION

Foods are exceedingly complex mixtures of chemicals substances. Apart from containing nutritionally important constituents, some foods also contain substances, which are harmful. The presence of nonnutritive constituents in foods represents potential health risks of different characters and magnitudes to persons consuming them. If such food is ingested, it can cause food poisoning and infection. Food poisoning could be caused by ingestion of foods containing certain chemicals, toxic plants or animals, toxins produced by bacteria and ingestion of animal parasites. Pathogenic microorganisms may enter foods through poor handling and grow in it. When such contaminated food is ingested, it could cause food infections. Hence, food safety should be a major concern of processor for the public health.

11.2 ANTI-NUTRITIONAL FACTORS

11.2.1 Anti-Nutritional Factors in Plant Foods

Plants are capable of synthesizing a multitude of chemical that cause toxic reaction when consumed. Pulses contain a number of toxic factors, such as protease inhibitors, lathyrogens and favism agents, cyanogens, haemagglutinins and saponins. Some of these toxins are also present in other foods, e.g., protease inhibitors in cereals and potatoes. Solanine, ordinarily the green parts of the potato are removed with the peel, is a toxicant in potatoes. Goitrogens (cause thyroid enlargement) are present in cabbage and related species, rapeseed and mustard. Some varieties of mushroom (e.g. Amanita) are poisonous. Oxalic acid present in spinach, beet etc may cause oxalic poisoning. Soybean contains trypsin inhibitor that affects protein metabolism. Cassava and Lima beans contain linmarin, a toxic glycoside. Lathyrism is a neurological disease caused by the ingestion of *Lathyrus sativus* (khesari dhal) for a period of 6 months or more. Favism agents in fava beans, gossypol in cottonseed are also potent toxic substances.

The active flavoring principles present in some spices may have toxic effects if consumed habitually over long periods or in excessive amounts. Active principles in some of the foods are allyl isothiocyanate in mustard, capsaicin in chillies, myristicin in nutmeg and mace, etc.

11.2.2 Toxicants in Animal Foods

The ingestion of shellfish (clams, mussels) results in paralytic shellfish poisoning. Saxitoxin, an extremely toxic metabolite, is p roduced from the plankton. The toxin resists ordinary cooking procedures. Sea food poisoning, for examples, ciguatera poisoning, moray eel poisoning, scombroid poisoning, puffer fish poisoning, cephalopod poisoning, is mostly prevalent in the areas where marine organisms constitute about 10 per cent of the diet.

11.3 CONTAMINATION OF FOOD BY MICROORGANISM, PATHOGENS

A large number of careless practices cause contamination of food with potentially pathogenic microorganisms. The more common ones are unhygienic practices of food handling, personnel handling food suffer from communicable diseases, cross contamination of food, contaminated water and containers, soil adhering to foods, insects, droppings of rodents.

Contamination by Bacteria

Certain bacteria release poisons known as toxins. Some toxins produced by *Clostridium botulinum* are often cause death of persons consuming food contaminated with this organism. The bacteria such as Staphylococcus aureus and Bacillus cereus produce toxins in food during multiplication or sporulation. Although cooking may destroy these bacteria but the toxin is unaffected and can still cause the problems if food is eaten. Endotoxin are generally produced by bacteria such as *Salmonella* in the intestines of persons consuming food contaminated with such organisms.

Contamination by Moulds

Almost any food can be invaded by mould growth. Moulds cause various degree of visible deterioration and decomposition of foods. Moulds may produce abnormal flavours and odours due to fermentative, lipolytic, and proteolytic changes caused by enzymatic reactions with carbohydrates, fats, and proteins, respectively in foods.

Contamination by Yeasts

Food that is highly contaminated with yeasts will frequently have a fruity odour. Yeasts can grow in a product with low sugar concentration. Most of them do not develop in solutions containing more than 66% sugar or 0.5% acetic acid. Boiling destroys the yeasts cells and spores completely. Foods liable to be spoiled by yeasts are fruit juices, syrups, molasses, honey, jams and jellies.

Contamination by Viruses

Viruses are transmitted to food by workers who are carriers. An infected food handler can excrete the organism through the faeces and respiratory tract infection. The inability of host cells to perform their normal function causes illness due to viral infection.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. 'Non-nutritive constituents of food can create potential health risks', justify.

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2. Write some of the important anti-nutritional substances present in vegetables.

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3. Define endotoxins. List the factors responsible for food contamination.

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11.4 FOOD INTOXICANTS

The undesirable constituents that affect the safety of foods include toxicants naturally occurring in foods, toxins resulting from microbial growth, environmental contaminants such as processing and accidental contaminants and chemical contaminants.

Naturally occurring toxicants in plant and animal foods

Foods contain thousands of compounds that are potentially toxic. For example protease inhibitors, lathyrogens, favism agents, cyanogens, haemagglutinins and saponins in pulses, solanine in potatoes, goitrogens in cabbage, rapeseed, etc., trypsin inhibitor in soybean, beta oxalyl amino alanine in khesari dhal, linmarin in cassava and lima beans, Favism agents in fava beans, gossypol in cottonseed are potent toxic substances. Some spices contain active principals (e.g., allyl isothiocyanate in mustard, etc.) may have toxic effects. Paralytic shellfish poisoning from oysters, calms, mussels, and scallops has caused many fatal illness. Saxitoxin, an extremely toxic metabolite, is produced from the plankton.

Microbial Toxins

Microorganisms promote desirable changes in foods under controlled conditions. However, they also cause harmful effect and are involved in most cases of food poisoning.

Bacterial food intoxication: Staphylococcal poisoning occurs abruptly after ingestion of food containing the enterotoxin, produced by staphylococci present in semisolid foods. Foods such as corn, peas, meat, fish are likely to be contaminated with the spore of Clostridium botulinum. They act on nervous system and are potent poisons and cause a disease known as botulism. The food infected with Bacillus cereus, if consumed is also harmful.

Some species of fungi such as Aspergillus flavus, Aspaergillus parasiticus (produced aflatoxins) Claviceps purpurea, Fusarium species produce toxins in foods infected with them and make the foods unfit for consumption.

Environmental Contaminants

These include residues that become part of food as a result of processing, handling and distribution of food. For examples, ethylene oxide used as fumigants to sterile some food reacts with inorganic chlorides to form ethylene chlorohydrin, which is toxic. During smoking of meat and fish for preservation and flavouring, these foods get contaminated with polycyclic aromatic hydrocarbons (e.g. benzopyrine), many of which are carcinogenic.

Metals, find their way into foods through air, water, soil, industrial pollution and many other routes, when present beyond the permissible limit, are toxic. Mercury, cadmium, lead, tin, etc. are the toxic metals present in foods.

Other contaminants from food processing such as lubricants, boiling water additives, packaging material, inside coating of the packaging materials, etc. may contaminate the food and their products and make them unfit for consumption.

11.5 MYCOTOXINS

Mycotoxins are toxic metabolites produced by various moulds when they grow on agricultural products before or after harvest, and during transportation or storage. Some moulds such as Aspergillus species and Penicillium species can invade grains after harvest and produce mycotoxins, while others such as Fusarium species, infect grains and produce mycotoxins before harvest. Mycotoxins remain in the food long after the mould producing them has died and can therefore, be present in foods that are not visibly mouldy. Further many mycotoxins, but not all, are stable and survive the usual conditions of cooking or processing.

Mycotoxins are undesirable because of their adverse effect on both human and animal health. Many mycotoxins have been found to occur naturally in a large number of commodities, but only few of these are widely accepted as causing significant food safety risks. Food grains, especially rye, bajra, sorghum and wheat have a tendency to get infected with the ergot fungus, Claviceps purpurea. Consumption of ergot infected grains leads to ergotism. Mycotoxins produced by certain moulds, Aspergillus flavus and Aspergillus parasiticus are known as aflatoxins. These fungi develop in many foods particularly in maize, sorghum, groundnut, etc. under improper storage conditions and produce aflatoxins of which B_1 and G_1 are the most potent hepatotoxins, in addition to being carcinogenic.

Moisture content of foods above 16 per cent and temperatures ranging from 11 to 37^0 C favour toxin formation. Fungal contamination can be prevented by proper storage after drying the grains to 10 per cent moisture level.

11.6 FOOD POISONING AND FOOD INFECTIONS

11.6.1 Food Poisoning

Food poisoning is an acute gastro-enteritis or any other disorder caused by ingestion of food contaminated with either living bacteria or their toxins or inorganic chemicals and poisonous plant and animal foods.

i) Food poisoning by microorganisms

Botulism is a severe form of food poisoning caused by ingestion of inadequately cooked canned food (beans, peas, etc.) contaminated with bacteria; Clostridium botulinum. The symptoms of botulism occur 18 to 36 hours after ingestion of contaminated food and begin in gastrointestinal tract. The principal hazard is the effect on the nervous system. Death may occur as a result of respiratory paralysis and cardiac failure.

Staphylococcal food poisoning is the most common form of food poisoning which occurs after ingestion of food contaminated with Staphylococcus aureus. Staphylococcus contamination of food may either be from human or animal sources. Some strains of *Staphylococcus aureus* can produce an enterotoxin. Staphylococcal food poisoning can be characterized by salivation, nausea, vomiting, abdominal cramps and diarrhoea. Pasteurization kills all the Staphylococci that may be present in foods but toxins may not be destroyed by pasteurization or ordinary boiling.

Salmonella food poisoning caused by the ingestion of foods particularly commercially prepared animal foods, contaminated with S. typhimurium, S. cholera-suis and S. enteritis besides many others. Salmonellosis may be characterized by enteric fever, gastro-enteritis.

Clostridium perfringens food poisoning: C. perfringens has been found in faeces, soil, water and air. The majority of this type of poisoning has been associated with ingestion of fresh or frozen meat, meat preparations and poultry. The common symptoms of this poisoning are diarrhoea, abdominal cramps and fever, occurring 8 to 24 hours after consumption of the food. The bacteria are destroyed by ordinary cooking temperature but spores survive at this temperature and need thorough cooking.

Cereus food poisoning caused by Bacillus cereus and their toxin, found in raw, dried and processed foods. The spores can survive at cooking temperature and multiply rapidly when food is held at room temperatures. The poisoning is characterized by gastro-intestinal tract symptoms.

Some of the species of fungi such as *Aspergillus flavus*, *Aspergillus parasiticus*, *Claviceps purpurea*, *Fusarium* species produced toxins in foods and make those foods unfit for human consumption.

ii) Contaminants arising from processing, accidental contaminants and chemicals

These include residues that become part of food as a result of processing, handling and distribution of food, e.g., fumigants. Ethylene oxide is a commonly used fumigant. Ethylene oxide reacts with inorganic chlorides to form ethylene chlorohydrin, which is toxic. Solvents like trichloroethylene, used for extraction of oil from oilseeds reacts with the substances and produce a toxic product.

During smoking of meat and fish for preservation and flavouring, these foods get contaminated with polycyclic aromatic hydrocarbons (e.g. benzopyrine), many of which are carcinogenic.

Metals find their way into foods through air, water, soil, industrial pollution and many other routes. Metals (mercury, lead, tin, aluminum, etc.) beyond the permissible limits are toxic.

Poisoning by chemicals is not very common. Poisonous chemicals like arsenic, cadmium, antimony can enter foods through improperly coated utensils. Insecticide and pesticides (malathion etc.) residues can also cause food poisoning if contaminated food is consumed without washing.

iii) Poisonous plants and animals

Certain varieties of mushrooms are very poisonous and could be fatal if consumed. Snakeroot poisoning could result from drinking milk from cows that have fed on this weed. Seafood such as mussels and clams sometimes contain a poisonous alkaloid. Death camas contains a poisonous alkaloid that decrease blood pressure if consumed. Bush tea contains toxic factors, which are known to cause occlusive disease of the liver, often leading cirrhosis. Pulses contain a number of toxic substances such as protease inhibitors, lathyrogens and favism agents, cyanogens, haemagglutinins and saponins. Saponins goitrogens, oxalic acid present in some foods can cause poisoning if consumed in large quantities. Gossypol is a toxicant found in cottonseed. Sea foods poisoning, toxicants present in certain spices and flavours. Toxic substances found in certain food fats cause food poisoning when consumed in large amounts.

11.6.2 Food Infections

Pathogenic microorganisms and parasites may enter foods through poor handling and grow in it. Food containing a large number of pathogens if ingested can cause food infections. Food borne infections are especially prevalent in communities with inadequate facilities for storing foods and insanitary water supplies and lavatories. The principal types of infectious organisms that may cause diseases are: bacteria, moulds and viruses.

Bacterial food infections result from the ingestion of large amount of viable bacteria, which multiply inside the host and cause infections. Some of the common infectious diseases caused by bacteria are:

- Cholera is one of the most acute and violent infections, characterized by fever, severe diarrhoea, abdominal cramps, vomiting, intense thirst followed by collapse. Cholera spreads from infected person and faecal-contaminated food and water.

- *Bacillus cereus* infection characterized by severe vomiting 1 hour after ingestion or diarrhoea later.

- Escherichia coli food infection is spread by contaminated food and water. It is characterized by gastroenteritis and most common infection in infants.

- Salmonellosis is characterized by diarrhoea, abdominal cramps and vomiting, which usually lasts for 2 to 3 days. Salmonella bacteria grow rapidly in cooked eggs, meat, custards and salads, which have been left at room temperature for several hours.

Some other bacterial infections, which are caused by ingestion of contaminated food, are tuberculosis and typhoid.

Many diarrhoeal diseases, viral hepatitis, gastroenteritis, etc. are transmitted primarily by faecal-oral route. Faecal oral transmission may be water born, food born, or direct transmission, which implies an array of other faecal-oral routs such as via fingers, or fomites, or dirt.

Parasitic Infestation of Foods

Many protozoa, helminthes (worms) gain admission to the body by means of food and cause injury to the intestinal lining and sometimes other tissues. Amoebiasis is a common infection of gastrointestinal tract, caused by potentially pathogenic strain of Entamoeba histolytica. The helminthes that frequently invade the intestinal tract include nematodes (round worms), cestodes (tapeworms), and trematodes (liver, intestinal, and lungs flukes). Tricinosis, one of the most serious infestation results from ingestion of raw or partially cooked pork infected with Trichinella spiralis, a very minute roundworm. Trichinella is destroyed by cooking pork, until no trace of pink remains. Foods act as a carrier for the parasites but none of these organisms grow in the food as such. Usually such contamination occurs due to poor handling of food and preparation.

11.7 FOOD BORN DISEASES

Food borne disease is caused by agents that enter the body through the ingestion of food. Food borne diseases may be classified as:

A) Food Borne Intoxications

i) Due to naturally occurring toxins in some foods, e.g., lathyrism, endemic ascites, etc.

ii) Due to toxins produced by certain bacteria, e.g., botulism, staphylococcal food poisoning.

iii) Due to toxins produced by some fungi e.g., aflatoxins, ergot, fusarium toxins, etc.

iv) Food borne chemical poisoning

- Heavy metals, e.g., mercury (in fish), cadmium (in certain shellfish), and lead (in canned food)
- Oils, petroleum derivatives and solvents
- Migrant chemicals from packaging materials
- Pesticide residues (DDT, BHC)

B) Food borne infections

i) *Bacterial infections:* typhoid, cholera, salmonellosis, shigellosis, etc.

ii) *Viral infection:* viral hepatitis, gastroenteritis

iii) *Parasitic infestations:* ascariasis, amoebiasis, trichinosis, etc.

(Details about food borne diseases was covered under food toxins, food poisoning and food infections)

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What is food poisoning? Explain with the help of examples.

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2. What do you understand by food borne diseases? Write the name of some common food borne infections.

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3. What are mycotoxins? Write a brief note on aflatoxins.

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4. What are different environmental contaminants that make the food unfit for consumption?

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11.8 METHODS OF PREVENTING FOOD CONTAMINATION

Contamination can be reduced through effective housekeeping and sanitation, protection of food during storage, proper disposal of garbage and litter, and protection against contact with toxic substances.

The Environment

Only cleaned hands should touch food during handling and processing. A processed product should be kept covered to prevent the entry of dust or other things. If the nature of food does not permit this kind of protection; it should be placed in an enclosed, dust free cabinet at appropriate temperature. Equipment and utensils for food processing, packaging, preparation, and service should be cleaned and sanitized between uses.

Storage

Storage facilities should provide adequate space with appropriate control and protection against dust, insects, rodents, and other extraneous matter. Organized storage layouts can reduce contamination and facilitate cleaning. In addition storage area floors shelves and/ or racks should be cleaned regularly. Waste materials should not be accumulated in the food storage area.

Litter and Garbage

Waste and refused materials (used packaging materials, containers and waste products) should be placed in appropriate containers for disposal. These receptacles should be seamless, with close fitting lids. Plastic liners are inexpensive and provide added protection. All receptacles should be washed and disinfected regularly. Containers kept in food processing and food preparation areas should not be used for garbage or litter, other than that produced in those areas.

Toxic Substances

Poisons and toxic chemicals should not be stored near food products. In fact, only chemicals (well labelled) required for cleaning should be stored in the same premises. Only cleaning compounds, supplies, utensils, and equipment approved by regulatory or other agencies should be used in food handling, processing, and preparation.

11.9 DEFICIENCY: PROTEIN, VITAMIN AND MINERAL – CONSEQUENCES AND CORRECTIVE MEASURES

As a consequence of dietary deficiency, several nutritional problems are encountered namely (i) PEM (ii) vitamin A deficiency, (iii) iron deficiency anaemia, (iv) iodine deficiency, (v) vitamin B-complex deficiencies.

Protein Deficiency

Protein energy malnutrition (PEM) is the name given to various degree of nutritional disorders caused by inadequate quantities of protein and energy in the diet of young children. This leads to various degree of growth retardation. When growth retardation is severe, functional deficiencies, like resistance to infection, poor intellectual development and body may have wasted away. Kwashiorkor and marasmus are two clinical forms of PEM at opposite poles of a single continuum. Kwashiorkor (growth failure, oedema, diarrhoea, fatty liver, dermatitis and other symptoms) occurs when there is a lack of protein in the diet but calories or energy in the form of carbohydrates is available in sufficient quantity. However, when both protein and energy are insufficient, over prolonged periods, a condition known as marasmus (growth failure, wasting of muscles, and dry and atropic skin and other symptoms) occurs in children. Both kwashiorkor and marasmus can be complicated with other infections due to intestinal parasites and bacteria.

The dietary management along with medical treatment for infection, if any is necessary for rapid recovery of the child with PEM. The diet should be rich in easily digestible proteins (4-5 g/ kg normal body weight of the child) of high nutritive quality (from milk and milk product, legumes, sprouts etc.), calories (140 Kcal/ kg body weight) and all dietary essentials (vitamin A and iron supplementation).

Vitamin Deficiencies

Vitamin A deficiency is a major nutritional problem in young children leading to blindness. Night blindness (inability to see in dim light), Conjuctival xerosis (conjuctiva becomes dry and non-wettable, appears muddy and wrinkled), Bitot’s spot (triangular, pearly-white or yellowish, foamy spots on the bulbar conjuctiva on either side of the cornea), corneal xesosis (cornea appears dull, dry, non wettable and eventually opaque) and keratomalacia (cornea may become soft and burst open) are important deficiency states due to vitamin A deficiency. The person with vitamin A deficiency should be given well balanced diet including green leafy vegetables and yellow and orange fruits in sufficient quantities with the vitamin A supplementation.

Vitamin D deficiency causes Rickets in children (characterized by enlarged joint, bowed legs, knocked knees, bulging forehead, pot belly, delayed eruption of temporary teeth, muscular hypotonia etc.) and Osteomalacia in adults, in which bones soften, become distorted, and fracture easily. The subjects (children or adults) should be given a well balanced diet containing plenty of milk, ragi, and green leafy vegetables along with calcium and vitamin D supplementation.

Vitamin C deficiency produces the disease scurvy characterized by swollen and inflamed gums, loss of weight, anaemia, poor wound healing, pain in joint and muscles. Severe form of scurvy is fatal. In addition to well balanced diets with sufficient amount of locally available fruits and germinated legumes, vitamin C supplementation is important.

Vitamin B-complex deficiencies commonly encountered are riboflavin deficiency leading to angular stomatitis, glossitis and cheilosis; thiamine deficiency leading beri-beri and niacin deficiency (Pellagra). Thiamine deficiency is prevalent in areas where polished rice is the staple food. Inclusion of under milled, or parboiled rice, whole wheat and wheat products, nuts, legumes could help to remove thiamine deficiency. Use of milk and milk products, eggs, green leafy vegetables could prevent riboflavin deficiency. Groundnuts are rich in niacin. Use of combination of cereals, pulses and inclusion of groundnuts would help in preventing vitamin B-complex deficiency.

Mineral Deficiencies

Nutritional aneamia and iodine deficiency are the major public health problems due to mineral deficiencies. Aneamia affects all segments of population in general and children, women and pregnant women in particular. Anaemia may be due to deficiency of iron, or folic acid or vitamin B_{12}. The incidence of anaemia can be reduced by inclusion of leafy vegetables, pulses, whole grains and vitamin C rich seasonal fruits in diet. Since change in dietary habits is a slow process, some interim public health measures have been taken to reduce the incidence of anaemia. These include distribution of tablets containing iron and folic acid at primary health centers. In order to combat and prevent iron deficiency anaemia, fortification of a universally consumed dietary item with iron can be one of the most effective methods.

The Iodine deficiency in man leads to a number of disorders, which include goiter, mental retardation, cretinism, myxoedema, and neuropsychic retardation. The simplest way of eradicating iodine deficiency is by consumption of iodized salt.

11.10 METHODS OF NUTRIENT RETENTION DURING PROCESSING AND STORAGE

Using food preparation methods maximizing nutrient retention is most important to maintain the quality of foods. The processing methods generally used in food preparation; also affect the nutritive quality of various foodstuffs.

i) Nutrients retention during milling

Milling of cereals like paddy to get rice causes considerable loss of vitamins, minerals and proteins. Parboiling of paddy can significantly reduce the nutritional losses during milling of paddy. During parboiling of paddy, B-vitamins present in the bran gets fixed to the grain and hence not removed during milling. Washing of rice before cooking in limited amounts of water also reduce the loss of thiamine due to leaching.

Nutritional loss also occurs during dehulling of pulses. The dehulling losses, in terms of broken and powder fractions can be reduced by following suitable pre-milling treatment (heat treatment or oil treatment etc.) and conditioning of legume seeds before dehulling.

ii) Prevent nutrients from leaching

Water leaches out some vitamins and minerals from the foods. Presoaking of food grains has negligible effect on nutrients such as proteins and fats but digestibility of starch improves. If soaking water discarded, reduction in some nutrients such as minerals and B-complex vitamins will occur. Rice should not be washed for longer time to avoid the loss of thiamine and niacin. The nutrients are also lost if water in which vegetables are cooked, discarded. Vegetables and fruits should be washed before cutting to avoid the leaching of nutrients in washing water.

iii) Avoid excessive heat treatment

Excessive heat destroys heat sensitive vitamins and decreases the protein quality. Preparing food in smallest amount of water at optimum temperature for the shortest time does least nutritional damage. Reheating of food products will add to the loss of nutrients. If required microwave heating for a few seconds may serve the purpose.

iv) Save foods from exposure to oxygen and light

Oxygen in the air and light decreases the amount of vitamins A, B_{12}, C, D, and E, folic acid, and thiamine in foods. Light also decrease the vitamin B_6 and riboflavin. Unsaturated fatty acids are unstable in the presence of air. Packaging of food material is an important measure to protect the foods from losses due to exposure to air and light.

v) Avoid wide changes in pH

pH is important because vitamin A and K and folic acid are unstable in an acidic environment, whereas, vitamin C, D, and K, pantothenic acid, riboflavin, and thiamine are unstable in an alkaline medium.

vi) Minimize trimming and peeling

Trimming and peeling should be kept to a minimum. The skin of fruits has valuable amounts of fibre and vitamin C. The outer leaves of vegetables are good sources of some vitamins and minerals.

vii) Careful handling of perishable foods

Removal of diseased, damaged and scratched fruits and vegetables during grading and post harvest treatment are highly useful in reducing the losses.

viii) Avoid the use of sodium bicarbonate to cooking water

Addition of sodium bicarbonate to hasten the cooking of dhal or to retain the colour of vegetables causes heavy loss of thiamin and vitamin C, hence should be avoided.

ix) Moisture content of food

For best storage and to prevent nutritional losses in food grains and oilseeds, these should be thoroughly cleaned, graded and dried to bring down the moisture content below 10 per cent.

x) Packaging

Packaging of foods particularly fruit and vegetables minimize physiological and biochemical changes. Packaging in modified atmospheric (MA) condition reduce the losses of vital nutrients during storage.

xi) Storage at low temperature

The loss of moisture is reduced by storing the vegetables in an atmosphere of high relative humidity at low temperature. Canned foods retain higher levels of vitamin C and thiamine if stored at low temperature. Roots and tubers can be stored at a temperature between 3 to 10^0C to keep sprouting minimum. Ageing of leafy and other vegetables, and fruits can be retarded by low temperature storage.

11.11 FOOD ANALYSIS, RESIDUE ANALYSIS

11.11.1 Food Analysis

Food analysis enables us to know the composition of fresh food and food products. A complete analysis of fruits and vegetable products includes determination of water content, protein, fat, nitrogen-free extract, fibre and ash. Each group is not made up exclusively of allied chemical substances, but rather of substances that happen to have one or more properties in common. The methods employed for the determination of these six constituents involves precipitation, colour comparison, or centrifuging or titration.

The water is determined by drying at $\leq 120^0$ C (depending on the commodity) in ovens for a certain period; the protein by calculation from the total nitrogen; total nitrogen by digestion (of sample), distillation and titration using some chemicals; the fat by ether extraction; the fibre by removal of all acid and alkali soluble constituents, and weighing the residue; the ash by incineration.

11.11.2 Residue Analysis

Residue analysis is concerned with the safety of food for human consumption. Whether applied to analysis of any kind of residue, all residue analysis has its ultimate aim; the capacity to identify food as safe or unsafe for human consumption. Residues analyses on food are undertaken for a very wide range of purposes. In the development of agrochemicals and veterinary drugs, for example, detailed studies on persistence of drugs in crops and/ or animal tissues post-treatment are required. In addition, studies on the metabolism of these chemicals require extensive residue analysis. For chemicals used in farming or occurring as contaminants from the environment and/ or industrial processes, residue analysis is undertaken as part of the monitoring programmes of regulatory agencies to ensure that residues, where they occur in foods, are at levels with respect to the established maximum residue limits (MRLs). In the case of prohibited substances, residue testing is designed to monitor compliance with the regulations. Generalized format for residue analysis is shown in Figure 11.1.

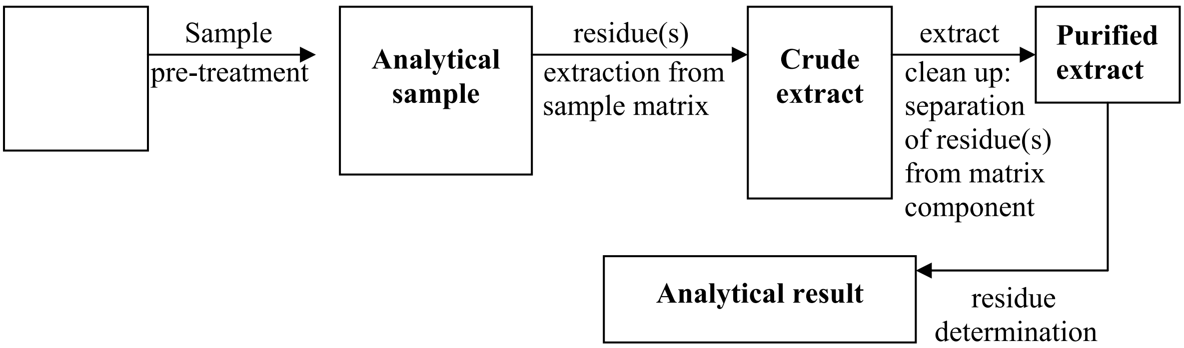

Figure 11.1: Generalized format for residue analysis

Within the spectrum of residue analysis methods, including screening, quantitative and confirmatory methods, there are methods ranging from single-step to multi-step methods. Example of the former are the four plate test for inhibitory substances in meat, for which all pre-determination steps are combined into a single step of cutting disc of frozen meat from the sample, placing them on prepared agar plates and incubating overnight, and a sol particle immunoassay (SPIA) test for sulphamethazine in urine, for which all pre-treatment steps are eliminated and the sample is applied directly to the test device. At other extreme are complicated methods with multiple steps such as methods for confirming the presence of residues of anabolic agents in tissues or bile. These methods involved weighing and homogenizing of sample, pH adjustment of the homogenate, overnight incubation with glucuronidase/ sulphatase to hydrolyse conjugates, extraction of residues directly with solvent or on a diatomaceous earth column, liquid/ liquid partitioning steps and multiple column chromatography or solid phase extraction (SPE) steps to remove co-eluting interferences, multiple evaporation of solvents, derivatisation of the residues and clean-up of the derivatised extracts, prior to determination by gas chromatography-mass spectrometry. In between these extremes lie the majority of residue methods but, in general, the extent of quantification and confirmation and the nature of the sample (solid or liquid) determine whether simple or more complex methods are used.

Table 11.1: Categories of chemical that can arise as residue in food

Category	Examples
a) *Natural*	
Normal components in food	Phytoestrogens, glycoalkaloids, erucic acid
Natural contaminants in food	Mycotoxins, phycotoxins (aquatic biotoxins)
b) *Synthetic*	
– Agricultural chemicals	– Pesticides, fertilizers
– Veterinary drugs	– Antibiotics, anthelmintics, growth promoters
– Food additives	– Preservatives, antioxidants
– Chemicals from packaging	– Vinyl monomers, oligomers
– Food processing chemicals	– Nitrosamines, polycyclic aromatic hydrocarbons (PAHs)
– Environmental contaminants	– Dioxins, polychlorinated biphenyls (PCBs)

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What is malnutrition? What is the most common form of under-nutrition prevalent amongst vulnerable group?

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2. Discuss different methods that can reduce the nutrients losses.

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11.12 LET US SUM UP

Some foods contain toxic constituents, if consumed in sufficient quantities may prove to be hazardous. The hazardous substances include toxicants naturally occurring in foods, toxins produced by microorganisms, and environmental contaminants. The microorganisms most common to food are bacteria and fungi; get their entry in food as a result of unhygienic practices during food handling, processing and storage. Bacterial contamination is the most significant as it may result in food poisoning. Botulism is the most fatal and Staphylococcal food poisoning is the most common form of food poisoning due to bacterial contamination of food. Contamination can be reduced by safe food handling practices, processing under sanitary conditions, protecting food during storage, proper disposal of waste materials, and protection against contact with toxic substances. These practices will not only reduce the contamination from toxicants but also the nutritional losses and thus prevent food losses and nutritional deficiencies amongst population.

11.13 KEY WORDS

Aneamia : is a condition characterized by reduction in red blood cells, packed cell volume or circulating haemoglobin, resulting in pallor appearance and shortness of breath especially on exertion.

Contamination : entry of undesirable organisms in some material or object.

Endotoxins : toxins produced inside the cell wall and can only permeate the food or the body when the organism is killed.

Exotoxins : toxic substances produced by bacteria which diffuse out of the cells and stimulate the production of antibodies.

Malnutrition : is a condition result from an inadequate (under nutrition) or excessive intake of one or more nutrients (over nutrition) or some defect in metabolism, which prevents the body from using the nutrients properly, e.g., PEM, Vitamin A deficiency, obesity.

Pathogens : disease causing microorganisms.

Toxicity : is the capacity of a substance when tested by itself to harm living organisms.

11.14 ANSWER TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

Your answer should include the following points:

1. Foods contain some anti-nutritional factors.

   Excess consumption over a long period can cause health problems, e.g. lathyrism. See sub-sec. 11.2.

2. Protease inhibitor and solanine in potatoes, goitrogens, oxalic acid. See sub-sec. 11.2

3. Some bacteria produced toxins inside the cell wall.

   Unhygienic practices, cross contamination of food, contaminated water and containers, soil adhering to foods, insects, droppings of rodents, etc. See Sub-sec. 11.3.

Check Your Progress Exercise 2

Your answer should include the following points:

1. Ingestion of contaminated food may result in food poisoning.

   Botulism, Staphylococcal food poisoning, Salmonellosis, Clostridium perfringens food poisoning, Cereus food poisoning, lathyrism. See sub-sec. 11.6 and 11.7.

2. Food may be contaminated by pathogenic organisms.

   Diseases caused by agents that enter the body through ingestion of contaminated food.

   Typhoid, cholera, salmonellosis, hepatitis, amoebiasis, etc. See sub-sec.11.6 and 11.7.

3. Moulds grow on agricultural products and produced toxic metabolites.

   Bacteria- Aspergillus flavus and Aspergillus parasiticus produce aflatoxins. See sub-sec. 11.5.

4. Residues in foods from fumigants, presence of metals beyond the permissible limits, chemical residues See sub-sec. 11.6.1.

Check Your Progress Exercise 3

Your answer should include the following points:

1. Undernutrition, over nutrition.

   PEM. See sub-sec. 11.10.

2. Parboiling, optimum heat treatment, save from exposure to oxygen and light, avoid wide changes in pH, careful handling of perishable foods, minimum trimming and peeling, storage at Low temperature. See sub-sec. 11.11.

11.15 SOME USEFUL BOOKS

1. Marriott Norman G. (1999) Principles of Food Sanitation (4th Edition), Aspen Publishers, Inc., Gaithersburg, Maryland.

2. Park, K. (1994) Textbook of Preventive and Social Medicine (14th Edition), Banarasi Das Bhanot Publishers, Jabalpur.

3. Ranganna, S. (1991) Handbook of Analysis and Quality Control for Fruit and Vegetable Products (2nd Edition), Tata McGraw-Hill Publishing Company Limited, New Delhi.

UNIT 8 NUTRITIONAL ASPECTS

Structure

8.0 OBJECTIVES

After reading this unit, you should be able to:

- explain food, nutrition, nutrients, optimum nutrition, under nutrition, assessment of nutritional status;
- describe the role of different foods in our body;
- describe balanced diets; and
- state the importance of nutritional labelling.

8.1 INTRODUCTION

We need food for growth, development and to lead a healthy life. Since all foods are not of same nutritional quality, man's ability to meet his nutritional requirement depends upon the type and quantity of foodstuffs included in diet. It is not only the purchasing power of food but also the knowledge and awareness about nutritional needs at different stages of life, which is of paramount importance for maintaining nutritional health. We should consider the nutritive aspects of food from two broad points of view: first, what nutrients do foods contain and their requirement; and second, what are the relative stabilities of these nutrients and how are they affected by processing and handling. A brief description of general principles underlying the nutritional aspects is presented in the following sub-section.

8.2 SCOPE AND IMPORTANCE

We require more than 45 different nutrients throughout our life. Food materials ingested by our body are digested, absorbed and metabolized. A number of foodstuffs have to be selected to get all nutrients. Our health depends on the type and quantity of foodstuffs we choose in our diet. For sustaining healthy and vigorous life, diet should be planned according to the principles of nutrition.

Good nutrition is the fundamental basic requirement for health, functional efficiency and productivity. Good nutritional status is achieved not through drugs, tablets and pills but through a well and balanced diet. There is no known nutritional deficiency disorder that cannot be prevented by proper diet. Only the need is to provide adequate information to the common man as to how his nutritional needs can be fully met through judicious use of foods available at his own doorstep. The affluent sections need to be informed of the deleterious effects of dietary excesses and errors and how these can be avoided.

8.3 NEED FOR ENERGY

We need energy for work and different body functions. Whatever our age and sex, we need energy for three important functions of our body.

a) Basal metabolism
b) Physical activities
c) Dietary thermogenesis

a) Basal metabolism

The energy metabolism of a subject at complete physical and mental rest and having normal body temperature and in post absorptive state (i.e. 12 hours after the intake of last meal/ food) is known as basal metabolism.

b) Physical activity

Any movement of the body, or even a small part of it, expends energy. Greater the movement, higher the energy requirement. The actual amount of energy requirements of a person are determined by body weight, age, type and intensity of activity, and duration of activity.

Table 8.1: Effect of Body weight and type of physical activity on energy requirement (Kcal/day) of a moderately active person

Body weight (kg)	Men			Women		
	Light activity	Moderate activity	Very active	Light activity	Moderate activity	Very active
50	2100	2300	2700	1800	2000	2330
55	2310	2530	2970	2000	2200	2600
60	2520	2760	3240	2160	2400	2830
65	2700	3000	3500	2340	2600	3055
70	2940	3220	3780	2520	2800	3290

c) Dietary thermogenesis

Thermogenesis can be induced by diet, which is called as dietary thermogenesis, specific dynamic action or thermic effect of food. It is the amount of energy utilized by the body to digest, absorb, transport and store the nutrients. It is between 5-10% of the total energy intake. For example, it was found that in a fasting dog requiring 400 kcal, feeding of 100 g carbohydrates produces 425 Kcal, 44.4 g of fat produces 416 Kcal and 100 g of proteins produces 520 Kcal of heat. The extra heat produced is obtained by oxidation of tissue constituents and the animal will be in negative energy balance. This stimulating effect of carbohydrates, fats and proteins on energy metabolism is called specific dynamic action. The SDA of proteins is highest (about 30 %) while that of carbohydrates and fats is only 6% and 4% respectively.

8.4 BASAL ENERGY METABOLISM

Biochemical reactions (when body is at rest) are necessary to provide energy for maintenance of normal body temperature, breathing, heartbeat, muscle tone and other essential activities of cells and tissues. The basal metabolic rate is an expression of the amount of calories expended hourly in relation to the surface area of the body (calories/ meter^2/ hour).

Basal metabolic rate (BMR) is influenced by following factors:

Body surface area: A person who is tall and has greater proportion of lean tissues normally requires more basal energy than a shorter person of same weight.

Age: Age affects BMR because it changes the lean body mass especially the amount of muscle. BMR is highest during first 2 years of life due to rapid growth and declines about 2 % per decade after 21 years of age.

Gender: In general BMR of women is lower (about 6-10 %) than men due to higher body fat and other factors.

Pregnancy produces a BMR 15-25 per cent above the normal. Lactation also increases BMR.

Sleep: BMR during sleep is about 5-10 per cent less than in waking sate.

Environmental temperature: BMR increases when environmental temperature is low. At high temperature, BMR may decrease to lower heat production by the body.

Recent exercise: Following a period of exercise BMR remains elevated for some time.

Health factors: An elevation of body temperature above 98.6^0 F increases BMR by 7 per cent for each degree. Prolonged undernutrition, hypothyroidism, depression etc. tend to decrease BMR. Hyperthyroidism, anger, fear and other strong emotions increase BMR.

8.5 ENERGY VALUE OF FOODS

The energy yielding food factors are carbohydrates, proteins and fats. Vitamins and minerals do not provide energy, although they take part in liberating energy. Within the body, nutrients providing energy are oxidized in the cells with the help of catalysts. The process is one of continuous utilization of oxygen and production of CO_2, water and heat:

Carbohydrates and fats $\xrightarrow{O_2}$ CO_2 + water + heat

Proteins $\xrightarrow{\text{Oxidation}}$ CO_2 + water + urea

The energy value of foods depends on the quantity of carbohydrates, fats and proteins present in them. This can be determined by oxidizing a known weight of food in an instrument called bomb calorimeter and measuring the heat produced. The energy value of foods can be expressed in terms of kilocalories (Kcal) or mega joules (MJ).

One kilo calorie = 4.186 kilo joules
1000 kilo calorie = 4.186×10^3 kilo joules or 4.186 mega joules
1 Mega joule = 1000 kilo joules
1 Mega joule = 239 Kcal
1 Kilo calorie = 4.186 kilo joules

Addition of ghee or oil or butter to a food during preparation will increase the calorie content of that food. The average calorific value of pure carbohydrates, fats and proteins determined using the bomb calorimeter are:

1 g carbohydrates	4.1 Calorie
1 g fats	9.45 Calorie
1 g proteins	5.65 Calorie

The physiological energy value of carbohydrates, fats and proteins are 4,9,4 after making allowances for losses in digestion and metabolism.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What do you understand by nutrition? Write the importance of different nutrients in our body in brief.

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2. Why do we need energy? Explain.

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3. Define basal energy metabolism. What do you understand by basal metabolic rate?

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8.6 NUTRITIVE VALUE OF FOODS

Foods can be broadly classified into (i) cereals and millets (ii) legumes and pulses (iii) oilseeds and nuts (iv) vegetables (v) fruits (vi) fats and oil (vii) egg, meat, fish and other animal foods (viii) milk and milk products (ix) starchy and sugary foods and (x) spices and condiments.

Cereal and millets

Cereals are the main source of energy in our diet. They contribute 70-80% of daily energy intake of majority of Indians. They also contribute significant quantities of proteins, calcium, and vitamin B complexes. Cereal proteins are deficient in an essential amino acid lysine. However, if supplemented with pulses rich in lysine, biological value of cereal products increases.

Cereals contain invisible fat that can meet more than 50 percent of our essential fatty acid requirement. Cereals are also fair source of calcium and iron. Ragi is rich in minerals especially calcium. Millets including ragi are rich in minerals and fibre. Millets are also rich in phytate and tannin, which bind minerals and hence interfere with their bioavailability. Cereals do not contain either vitamin C or vitamin A except that yellow maize and some varieties of sorghum contain small amounts of β-carotene.

Legumes and pulses

Pulses are rich source of protein but do not contain vitamin C. They are a good source of B vitamins also. Germinated legumes are good source of vitamin C. Fermentation also improves the nutritive value particularly thiamin and niacin are enhanced. Legumes and pulses are also deficient in vitamin A, D, and B_{12}.

Khesari dhal, consumed in some parts of the country may cause lathyrism if the consumption is more than 300 gm/day for 6 months.

Table 8.2: Nutrients content of some commonly used cereals, legumes & nuts (values/ 100 g)

Particulars	Calories (Kcal)	Protein (g)	Fat (g)	Fibre (g)	Calcium (mg)	Iron (mg)	Carotene (μg)
Bajra or pearl millet	360	11.6	5.0	1.2	0.05g	8.8	132
Barley	335	11.5	1.3	3.9	0.03g	3.7	10
Maize, dry	342	11.1	3.6	2.7	10	2.3	90
Rice (raw, milled)	345	6.8	0.5	0.2	10	0.7	-
Rice, puffed	325	7.5	0.1	0.3	23	6.6	-
Whole wheat flour	341	12.1	1.7	1.9	48	4.9	-
Wheat bread, white	245	7.8	0.7	0.2	11	1.1	-
Bengal gram, whole	360	17.1	5.3	3.9	202	4.6	189
Bengal gram dhal	372	20.8	5.6	1.2	56	5.3	129
Black gram dhal	347	24.0	1.4	0.9	154	3.8	38
Rajmah	346	22.9	1.3	4.8	260	5.1	-
Red gram dhal	335	22.3	1.7	1.5	73	2.7	32
Almond	655	20.8	58.9	1.7	230	5.09	0
Coconut dry	662	6.8	62.3	6.6	400	7.8	0
Gingelly seeds	563	18.3	43.3	2.9	1450	9.3	60
Groundnut	567	25.3	40.1	3.1	90	2.5	37

Source: Nutritive value of Indian Foods, 1991.

Nuts and oilseeds

Nuts and oilseeds (except coconut) are rich in proteins containing about 18-40 per cent. Soybean is the richest source in proteins (containing about 40 per cent). They do not contain much carbohydrates but are rich in B-vitamins. Groundnuts are particularly rich in thiamin and niacin. Sesame seeds are rich in calcium.

Fats and oils

Fats and oils provide energy; vitamin A, E, D and K. Vegetable oils contain vitamin E and essential fatty acids (viz. linoleic and linolenic acids) except coconut and palm oils. Vegetable oils do not contain vitamin A and D except red-palm oil, which is exceptionally rich in carotene, a precursor of vitamin A.

Table 8.3: Nutritive values of fats (per 100 g)

Particulars	Moisture (%)	Fat (%)	Energy (Kcal)	Vitamin A (I.U.)	Vitamin E (mg)
Butter	14	86	774	700	2.4
Ghee	-	100	900	600	2.0
Vegetable oils and fats	-	100	900	-	8-140
Red palm oil	-	100	900	4000-10,000	10-15
Margarine#	14	86	774	700	10-50
Vanaspathi#	-	100	900	700	10-30

Processed fat

Vegetables

Vegetables are termed as 'protective foods' due to their high vitamins and mineral content. These generally have high water content, low protein and energy and varying amount of dietary fibre. Vegetables can be broadly grouped into green leafy vegetables, roots and tubers, and other vegetables. Green leafy vegetables are good source of calcium, iron, carotene, dietary fibre, vitamin C and vitamin B-complexes except vitamin B_{12}.

Table 8.4: Nutritional compositions of green leafy vegetables

Constituents	Range of values (per 100 g)
Moisture (g)	79-92
Energy (Kcal)	32-96
Carbohydrates (g)	4-14
Proteins (g)	109-607
Fat (g)	0.1-1.7
Calcium (mg)	30-500
Iron (mg)	0.8-16.0
Carotene (μg)	1200-7500
Vitamin C (mg)	48-200
Thiamin (mg)	0.05-0.16
Riboflavin (mg)	0.11-0.34
Nicotinic acid (mg)	0.4-1.8
Folic acid (mg)	10-30
Total dietary fibre (g)	2-6

Roots and tubers are rich in carbohydrates mainly starch and provide energy. In general, these are poor in proteins, vitamin and minerals but carrot and yellow flesh variety of sweet potato, and yellow yam are good sources of carotene. Potato is a fair good source of protein and vitamin C. Tapioca and yam are rich in calcium. Other vegetables (brinjal, okra, beans, all gourds, pumpkin, etc) not only provide variety to the diet but also provide vitamin C, some minerals, and fibre and thus add bulk to the diet.

Fruits

Fruits are priced for their vitamin and minerals content. Amla (600 mg/ 100g), guava (212 mg/ 100g) are rich source of vitamin C. Some fruits like banana and mango provide high calorie because of high sugar content. Eating fruits raw and fresh makes the vitamins and minerals present in them easily available to the body. Dried fruits like raisins, dates and apricots are good source of iron and calcium. Fruits also contain dietary fibre.

Foods from animal origin

Milk is almost a complete and ideal food. Milk and milk products like paneer, curd, khoa, etc. are good source of proteins, calcium, riboflavin and vitamin B_{12} but very poor in iron and vitamin C content. Milk does not contain vitamin E.

Eggs contain all nutrients except vitamin C and dietary fibre. Eggs contain proteins of very high biological value. Egg white contains about 12% proteins and some of B-vitamins but is devoid of fat and vitamin A. Egg yolk contains about 15% proteins, 3% fat, rich in vitamin A, iron, B-vitamins and vitamin D.

Flesh foods like meat, poultry and fish are rich in good quality proteins (18-22%) and vitamin B-complexes. Meat does not contain vitamin A, C and D. Fatty fish contain some vitamins A and D. Liver is rich in vitamin A and richest source of vitamin B_{12}.

Table 8.5: Nutritive value of some commonly used foods of animal origin (values/ 100 g)

Particulars	Calories (Kcal)	Protein (g)	Fat (g)	Calcium (mg)	Iron (mg)	Carotene (μg)
Milk (cow's)	67	3.2	4.1	120	0.2	174
Curd (cow milk)	60	3.1	4.0	149	0.2	102
Egg (hen)	173	13.3	13.3	60	2.1	600
Mutton (muscle)	194	18.5	13.3	150	2.5	0
Pork (muscle)	114	18.7	4.4	30	2.2	0

Other foods

Foods like sugar, jaggery, glucose, honey, custard powder, sago etc. mainly contain carbohydrates and provide energy.

Condiments and spices are accessory foods used for flavouring purposes to enhance the palatability of products. These are used in small amounts and their contribution to nutrient intake is very limited.

8.7 FOOD PYRAMID

The food pyramid is an outline to show the groups of foods that make a balanced diet. It is a general guideline that lets you choose a variety of foods from different food groups to get the various nutrients in right proportions. Its pyramid shape helps to explain which foods should be eaten more or less. The foods that make up the base of the pyramid i.e. widest part should provide the bulk of our diet. As you go up the pyramid, the amounts of different foods get smaller. Each of these food groups provide some, but not all, of the nutrients we need. Foods in one group can't replace those in another. No one-food group is more important than another - for good health, we need them all. The USDA has made some recommendation and provides a set of guidelines for healthy eating, represented in Figure 8.1.

Figure 8.1: Food pyramid

New guidelines emphasise more as weight control, whole grains, plant oils, vegetables & fruits and less on consumption of red meat, butter and refined foods such as white rice, white bread, pasta, etc.

8.8 DIGESTIVE PROCESS

Food do not get absorbed into the body as such except only a few substances namely water, simple sugars and some of mineral salts and vitamins. The principal component of food namely carbohydrates, fats and proteins undergo digestion.

8.8.1 Digestion of Carbohydrates

Digestion of cooked starch by salivary amylase begins in the mouth. This continues in the stomach for 10-15 minutes, till the food get mixed with gastric juice and action of amylase ceases due to high acidity.

A greater part of starch and glycogen present in food is digested by pancreatic amylase in small intestine.

- Starch and glycogen $\xrightarrow{\text{Pancreatic amylase}}$ Maltose + Isomaltose
- Sucrose $\xrightarrow{\text{Sucrase}}$ Glucose + Fructose
- Maltose $\xrightarrow{\text{Maltase}}$ 2 molecules of glucose
- Lactose $\xrightarrow{\text{Lactase}}$ Glucose + Galactose
- Isomaltose $\xrightarrow{\text{Isomaltase}}$ 2 molecules of glucose

The resulting monosaccharides viz. glucose, fructose, galactose are absorbed in small intestine. Cellulose, hemicellulose, pectin etc. are not digested and excreted as such.

8.8.2 Digestion of Proteins

Hydrolysis of proteins is accomplished by proteases secreted in gastric juice, pancreatic juice and in the small intestine.

Gastric digestion: The proteolytic enzyme present in gastric juice is pepsin. Since food remains in stomach for short time, pepsin hydrolyses dietary proteins mainly into a mixture of polypeptides.

Dietary protein $\xrightarrow{\text{Pepsin}}$ Polypeptides

Digestion in small intestine: The main digestion of polypeptides produced in stomach takes place in small intestines. The proteases involved in digestion are trypsin, chymotrypsin and carboxypeptidase secreted in pancreatic juice and amino peptidases present in intestinal mucosa.

- Protein and Polypeptides $\xrightarrow{\text{Trypsin and Chymotrypsin}}$ Peptide + amino acids
- Peptides $\xrightarrow{\text{Carboxy peptidase}}$ Amino acids
- Peptides $\xrightarrow{\text{Amino peptidases}}$ Amino acids
- Dipeptides $\xrightarrow{\text{Dipeptidase}}$ Amino acids
- Tripeptides $\xrightarrow{\text{Tripeptidases}}$ Amino acids

The resulting amino acids are absorbed in small intestine.

8.8.3 Digestion of Fat

Almost all fats present in our meal are triglycerides. Only a small fraction of dietary fat consists of cholesterol esters and phospholipids. Fats are primarily hydrolyzed in the small intestine. In stomach gastric lipase brings about some hydrolysis of finely divided fats only such as egg yolk and cream. Brief description of digestion and absorption of fat is given below.

Reaction in intestinal lumen		Reaction within intestinal wall	Mode of entry into circulation
Fat (Triglyceride) ↓ Lipase	3-10% absorbed as micelle →	Triglycerides and diglycerides may be hydrolysed by intestinal lipase into monoglycerides & fatty acids	Lymphatic vessels (lacteals)
Diglycerides + fatty acids ↓ Lipase	3-10% absorbed as micelle →		
Monoglycerides + fatty acids ↓ Lipase	60-68% absorbed as micelle →	Resynthesis of neutral fat, Phospholipids and cholesterol esters and formation of chylomicrons	
Glycerol+ fatty acids	20% absorbed as micelle		
Phospholipids ↓ Phospholipase			
Glycerol + fatty acids + phosphoric acid + organic base	(choline etc.) Absorption →		
Cholesterol esters ↓ Cholesterol esterase			Portal blood
Cholesterol + fatty acids	Absorption →	↑	
Short chain fatty acids (C_4-C_{10})	Absorption →	Short chain fatty acids (C_4-C_{10}) →	Short chain fatty acids (C_4-C_{10})
→ Glycerol	Absorption →	Glycerol →	Glycerol

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.

b) Compare your answers with those given at the end of the unit.

1. What are different foods? Write the importance of fruits and vegetables.

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2. Define food pyramid. What is the importance of food pyramid in food selection for the diet?

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3. Explain the term ‘digestion’. Write the different enzymes, which are important for digestion of carbohydrates, proteins and fats.

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8.9 DIETARY ALLOWANCES, STANDARDS AND BALANCED DIETS FOR DIFFERENT AGE GROUPS: CHILDREN, ADULTS, PREGNANT AND LACTATING WOMEN, OLD PEOPLE

8.9.1 Dietary Allowances and Standards

Dietary allowances are measures of nutritional need in terms of specific amount of nutrients that a person should receive every day to achieve full growth and development potential. The Nutrition Advisory Committee of Indian Council of Medical Research (1989) recommended the dietary allowances of different nutrients, which are presented in Table 1.11. Reference man is between 20-39 years of age, weighs 60 kg, free from diseases and physically fit for active work. Reference woman is between 20-39 years, weighs 50 kg and healthy.

8.9.2 Balanced Diets for Different Age Groups

A balanced diet is one which includes a variety of foods in such quantities and proportion that the need for nutrients is adequately met to promote and maintain the health. Food requirement will differ according to age, sex, physical activity, and physiological state viz. pregnancy, lactation etc.

Balanced diets for different age groups, sex, moderate activity and physiological state are given in Table 8.6 to 8.10. These diets are formulated using food exchange system suggested by Gopalan et al. (1991) and recommended dietary allowances of nutrients for Indians (I.C.M.R, 1989).

The food stuffs given in these tables should be considered as raw food items that represent a food group, for example, cereals may include wheat, bread, rice, puffed rice, maize etc. depending upon the dietary habits of individual/ family.

Mother's milk is the best food for newborns and infants up to 6 months of age. Afterwards, supplementary foods along with milk, is necessary. Strained fruit juices and soups, mashed banana, papaya, sago porridge, rice porridge, soft boiled egg yolk, mashed and well cooked khitcheri etc. may form the supplementary foods for the infants.

Table 8.6: Balanced diets for children (1-9 years old)

Food stuffs (g/caput/day)	**1-3 years**		**4-6 years**		**7-9 years**	
	Veg.	**Non-veg.**	**Veg.**	**Non-veg.**	**Veg.**	**Non-veg.**
Cereals	120	120	200	200	250	250
Pulses	20	20	40	40	50	50
Green leafy vegetables	50	50	50	50	50	50
Other vegetables	30	30	50	50	75	75
Fruits	50	50	50	50	100	100
Milk*	400	300	400	300	400	300
Fats and oils	20	20	20	20	25	30
Sugar and jaggery	20	20	40	40	30	30
Eggs or meat	-	50	-	50	-	50
Approximate nutrients						
Carbohydrates	158	153	256	251	334	284
Proteins	34	36	47	49	53	57
Total fats	46	46	46	46	41	56
Energy (kcal)	1258	1228	1689	1659	1933	1946

*****Buffalo milk. If cow milk is to be taken, increase the amount by one and half times

Table 8.7: Balanced diet for boys

Food stuffs (g/caput/day)	10-12 years		13-15 years		16-18 years	
	Veg.	**Non-veg.**	**Veg.**	**Non-veg.**	**Veg.**	**Non-veg.**
Cereals	300	300	350	350	390	390
Pulses	50	50	50	50	60	60
Green leafy vegetables	75	75	100	100	100	100
Other vegetables	75	75	100	100	100	100
Fruits	100	100	50	50	50	50
Milk	400	300	400	300	400	300
Fats and oils	30	30	30	30	30	30
Sugar and jaggery	40	40	25	25	30	30
Groundnut	25	25	25	25	25	25
Eggs or meat	-	60	-	60	-	60
Approximate nutrients						
Carbohydrates	394	345	381	376	423	367
Proteins	58	63	71	75	77	83
Total fats	43	57	66	67	66	86
Energy (kcal)	2189	2182	2451	2437	2640	2635

Table 8.8: Balanced diets for girls

Food stuffs (g/caput/day)	10-12 years		13-18 years	
	Veg.	**Non-veg.**	**Veg.**	**Non-veg.**
Cereals	250	250	250	250
Pulses	50	50	50	50
Green leafy vegetables	75	75	150	150
Other vegetables	50	50	100	100
Fruits	100	100	50	50
Milk	400	300	400	300
Fats and oils	30	30	25	25
Sugar and jaggery	30	30	25	25
Groundnut	25	25	25	25
Eggs or meat	-	60	-	60
Approximate nutrients				
Carbohydrates	298	293	303	299
Proteins	54	28	61	64
Total fats	56	57	51	62
Energy (kcal)	1972	1959	2083	2070

Table 8.9: Balanced diet for adult man & woman (moderate worker)

Food stuffs (g/caput/day)	Man		Woman			
	Veg.	**Non-veg.**	**Veg.**	**Non-veg.**	**Pregnancy***	**Lactation***
Cereals	490	490	350	350	-	25
Pulses	60	50	50	40	25	25
Green leafy vegetables	100	100	150	150	50	-
Other vegetables	100	100	100	100	-	-
Fruits	100	100	100	100	50	50
Milk	300	200	300	200	200	200
Fats and oils	40	40	30	30	-	10
Sugar and jaggery	40	40	25	25	-	10
Eggs or meat	-	90	-	90	-	-
Approximate nutrients						
Carbohydrates	507	496	377	366	38	60
Proteins	76	82	60	65	14.5	17
Total fats	59	65	49	55	13	23
Energy (kcal)	2871	2858	2228	2215	357	554

* additional allowances (in addition to normal diet) during pregnancy/ lactation

Table 8.10: Balanced diet for an aged person (60-70 years)

Food stuffs (g/caput/day)	Man		Woman	
	Veg.	**Non-veg.**	**Veg.**	**Non-veg.**
Cereals	325	325	225	225
Pulses	50	50	50	50
Green leafy vegetables	100	100	100	100
Other vegetables	150	150	150	150
Fruits	200	200	200	200
Milk	300	200	300	200
Fats and oils	20	20	20	20
Sugar and jaggery	20	20	20	20
Eggs	-	50	-	50
Meat	-	30	-	30
Approximate nutrients				
Carbohydrates	363	358	283	278
Proteins	58	63	48	53
Total fats	40	42	40	42
Energy* (kcal)	2084	2087	1744	1747

*Due to reduced basal Metabolic Activities, energy requirement in this age group is reduced by 20 per cent

Table 8.11: Recommended dietary allowances for Indians

Group	Particulars	Body wt. (kg.)	Energy kcal/d	Protein g/d	Fat g/d	Ca mg/d	Iron mg/d	Vit.A μg/d	Thiamin mg/d	Riboflavin mg/d	Niacin mg/d	Pyri-doxin mg/d	Vit.C mg/d	Folic acid mg/d	Vit.B mg/d
Man*	SW	60	2425	60	20	400	28	600	1.2	1.4	16	2.0	40	100	1
	MW	60	2875	60	20	400	28	600	1.4	1.6	18	2.0	40	100	1
	HW	60	3800	60	20	400	28	600	1.6	1.9	21	2.0	40	100	1
Woman*	SW	50	1875	50	20	400	30	600	0.9	1.1	12	2.0	40	100	1
	MW	50	2225	50	20	400	30	600	1.1	1.3	14	2.0	40	100	1
	HW	50	2925	50	20	400	30	600	1.2	1.5	16	2.0	40	100	1
	Pregnancy		+300	+15	30	100	38	600	+0.2	+0.2	+2	2.5	40	400	1
	Lactation														
	0-6 months		+550	+25	45	1000	30	950	+0.3	+0.3	+4	2.5	80	150	1.5
	6-12months		+400	+18	45	1000	30	950	+0.2	+0.2	+3	2.5	80	150	1.5
Infants	0-6 months	5.4	108/kg	2.05 kg		500	-	-	55μg/kg	65μg/kg	710 μg/kg	0.1	25	25	0.2
	6-12months	8.6	98/kg	1.65/kg	-	500	-	350	50μg/kg	60μg/kg	650 μg/kg	0.4	25	25	0.2
Children	1-3 years	12.2	1240	22	25	400	12	400	0.6	0.7	8	0.9	40	30	0.2
	4-6 years	19.0	1690	30	25	400	18	400	0.9	1.0	11	0.9	40	40	1.0
	7-9 years	26.9	1950	41	25	400	26	600	1.0	1.2	13	1.6	40	60	
Boys	10-12 years	35.4	2190	54	22	600	35	600	1.1	1.3	15	1.6	40	70	0.2-1.0
Girls	10-12 years	31.5	1970	57	22	600	19	600	1.0	1.2	13	1.6	40	70	0.2-1.0
Boys	13-15 years	47.8	2450	70	22	600	41	60	1.2	1.5	16	2.0	40	100	0.2-1.0
Girls	13-15 years	46.7	2060	65	22	600	28	600	1.0	1.2	14	2.0	40	100	0.2-1.0
Boys	16-18 years	57.1	2640	78	22	500	50	600	1.3	1.6	17	2.0	40	100	0.2-1.0
Girls	16-18 years	49.9	2060	63	22	500	30	600	1.0	1.2	14	2.0	40	100	0.2-1.0

* Reference man/ woman

8.10 TECHNIQUES FOR ASSESSMENT OF HUMAN NUTRITION

The nutritional status of an individual is influenced by food intake both in terms of quantity and quality and also by physical health of the person. The main objective of nutritional assessment is to obtain precise information on prevalence and geographical distribution of nutritional problems of a given community and identifying the individuals or groups of people 'at risk' or in a greatest need of nutritional assistance.

The assessment of nutritional status involves various techniques viz. clinical examination, anthropometry, biochemical evaluation, assessment of dietary intake, vital and health statistics, ecological studies.

Clinical Assessment of Nutritional Status

There are a number of physical signs, some specific and many non-specific known to be associated with states of malnutrition. Clinical signs, which are useful in assessment of nutritional status are: moon face, angular stomatitis, xerosis of conjuctiva, Bitot's spots, magenta tongue, etc. However, malnutrition cannot be quantified on the basis of clinical signs and many deficiencies are unaccompanied by physical signs.

Anthropometric Measurements

Anthropometric measurements such as height, weight, skin fold thickness and arm circumference are valuable indicators of human nutrition. In young children, additional measurements such as head and chest circumference are good indicators.

Laboratory and Biochemical assessment

Haemoglobin estimation is, most common laboratory test carried out to assess the prevalence of anaemia. Stools are examined for intestinal parasites. Urine is examined to assess the presence of albumin and sugar, etc.

Biochemical tests are applied to measure nutrient concentration in body fluids (e.g. serum iron, serum albumin, etc.) or detection of abnormal amounts of metabolites in urine (e.g. urinary creatinine, etc.) or measurement of enzymes in which the vitamin is a known co-factor (as in riboflavin deficiency) to assess malnutrition in its preclinical stages.

Radiological and Biophysical Assessment

Radiological examination may help in diagnosis of rickets, osteomalacia, infantile scurvy, beriberi, fluorosis, and protein-calorie malnutrition.

A large number of tests have been devised to assess dark adaptations of the eye, nerve accommodation, physical performance, muscle co-ordination etc., in different deficiency states to assess the degree of alteration in physiological function.

Assessment of Dietary Intake

Assessment of food consumption involves dietary surveys, which may be household inquiries, or individual food consumption surveys. A diet survey may be carried out by one of the methods viz. weighment of raw foods, weighment of cooked foods, oral questionnaire method to get information about dietary intake patterns; specific food consumed and estimated nutrient intakes.

Vital Statistics

An analysis of vital statistics – mortality (infant mortality rate, rate of low birth weight babies etc.) and morbidity data (hospital data or data from community health and morbidity surveys) particularly protein energy malnutrition, anaemia, xeropthalmia and other vitamin deficiencies, endemic goiter, diarrhoea, measles and parasitic infestations can be of value in providing additional information contributing to nutritional status of the community.

Ecological Studies

Malnutrition is the end result of many interacting ecological factors. A study of ecological factors comprises of food balance sheet, socio-economic factors (family size, occupation, income, education, customs, cultural influences etc.), health and educational services (primary health care services, feeding and immunization programme), and conditional influences (e.g., parasitic, bacterial and viral infections etc.).

8.11 NUTRITIONAL LABELLING

Labelling for nutrition information has been mandatory for (i) any food to which a nutrient has been added – enrichment, fortification, or restoration and (ii) any food for which a claim is made for nutritional properties either on the label or in advertising. All food for special dietary use require labelling. At present most nutrition labelling is voluntary, but many manufacturers have adopted it for their products.

Reasons for nutrition labelling:

- The main reason for nutrition labelling is to make the consumer aware about the nutritional properties of the product.
- Labelling also leads food processors to be constantly aware of the nutritive values of foods that they produce.
- Labelling will help persons who require modified diets to select those foods appropriate for their needs.

Regulations for nutrition labelling established by the Food and Drug Administration (FDA) are presented in Figure 8.2.

NUTRITION INFORMATION
(PER SERVING)
SERVING SIZE = 8 OZ.

SERVINGS PER CONTAINER = 1

CALORIES……………..…560	FAT (PERCENT OF CALORIES 53%)….……..33 GM
PROTEIN …….…………23 GM	POLYUNSATURATED*...2 GM
CARBOHYDRATE …….43 GM	SATURATED …………….9 GM
	CHOLESTEROL* (20 MG/100 GM)…………40 GM
	SODIUM (365 MG/ 100 GM) …………………830 MG

PERCENTAGE OF U.S. RECOMMENDED DAILY
ALLOWANCES (U.S. RDA)

PROTEIN ……………………...…35	RIBOFLAVIN ……..…..15
VITAMIN A ………………….…35	NIACIN ……………..…25
VITAMIN C (ASCORBIC ACID).……………10	CALCIUM…………...…..2
THIAMIN (VITAMIN B_1) ……. 15	IRON ………………..…25

*Information on fat and cholesterol content is provided for individuals who, on the advice of a physician, are modifying their total dietary intake of fat and cholesterol

Figure 8.2: The nutrition label format (U.S. FDA)

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What do you understand by dietary allowances? Write the requirements of fruits and vegetables in our daily diet.

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2. List the various techniques involves in assessment of nutritional status. What are various anthropometric measurements?

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3. Nutritional labelling helps the consumer in products selection. Justify.

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8.12 LET US SUM UP

Food is essential for our health and vitality. It is the food that provides us nourishment to perform various voluntary and involuntary functions of our body and prevents from deficiency diseases. Purchasing power of food and nutritional knowledge and awareness about nutritional need are the most important factors that affect the dietary consumption and nutritional health of a person and of any community.

It is the food pyramid which is a good guide in choosing a variety of foods from different food groups to get the required nutrients. Nutritional labelling also makes us aware about nutritional properties of purchased products.

8.13 KEY WORDS

Absorption : Transfer of nutrients across cell membranes; following digestion, nutrients are transferred from the intestinal lumen across the mucosa and into the blood and lymph circulation.

Digestion : Hydrolysis of foods in the digestive tract to simpler substances so that they can be used by the body.

Health : State of complete physical, mental and social well being and not just absence of disease.

Kilo Calorie : Kilo Calorie is the quantity of heat required to raise the temperature of 1 kg of water through 1^0C.

Metabolism : Physical and chemical changes occurring within the organism; includes synthesis of biological materials and breakdown of substances to yield energy.

Enzyme : An organic compound which can be protein or RNA produced by living tissue to accelerate certain specific metabolic reactions, viz. hydrolases, oxidases, peptidases and others.

Cholesterol : The commonest member of sterol group; synthesize by body and is essential for its functions.

8.14 ANSWER TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

Your answer should include the following points:

1. We need nourishment to perform various voluntary and involuntary body functions.

   The nutrients; carbohydrates, proteins, fats, vitamins and mineral are required by body to provide energy, development of body tissue, bones, teeth etc. See Sub-sec. 8.1, 8.2 and 8.5.

2. Basal metabolism

   Physical activities

   Dietary thermogenesis. See Sub-sec. 8.

3. Some of the energy is required at rest.

   Basal metabolic rate is the amount of calories required in the state of complete rest.

   Basal metabolic rate is influenced by body surface area, gender, age, health factors, sleep etc. See Sub-sec. 8.4

Check Your Progress Exercise 2

Your answer should include the following points:

1. Broadly foods can be classified in to ten different groups.
   Fruits and vegetables are termed as protective foods.
   Fruits and vegetables provide vitamins and minerals. See sub-sec. 8.6.

2. Food pyramid shows the food groups.
   Food pyramid helps in selecting balanced amount of foods. See sub-sec. 8.7

3. Hydrolysis of food is essential for absorption of different nutrients. Amylase, proteases, lipase etc. are enzymes essential for digestion of food. See sub-sec. 8.10.

Check Your Progress Exercise 3

Your answer should include the following points:

1. Dietary allowances are measures of nutrients that we need to take daily.

   An amount of 100 g of each of fruits, green leafy vegetables and other fruits can fulfil our daily requirements. See sub-sec. 8.9.2. and Tables 8.1 to 8.5.

2. Clinical examination, anthropometry, biochemical evaluation, assessment of dietary intake, vital and health statistics, ecological studies are techniques for nutritional assessment.

   Important anthropometric measures are height, weight, skin fold thickness, arm circumference, head and chest circumference. See sub-sec. 8.10.

3) Nutritional labelling is helpful in selecting nutritious products from variety of available products.

   FDA has established regulations for nutrition labelling. See sub-sec. 8.11

8.15 SOME USEFUL BOOKS

1. Gopalan, C. and Shastri, Rama, Balasubramanian, S.C. (2002) Nutritive Value of Indian Foods, National Institute of Nutrition, ICMR, Hyderabad, India.

2. Mridula, D. and Bisht, B.S. (2000) Food Facts and Diets, Central Institute of Post Harvest Engineering and Technology, Ludhiana, India.

3. Mudambi, S.R. and Rajagopal, M.V. (1982) Fundamental of Foods & Nutrition (Third Edition), Willey Eastern Limited, New Delhi.

4. Swaminathan, M. (1991) Advanced Text Book on Food and Nutrition Volume I, Bangalore Printing and Publishing Company, Bangalore.

5. Swaminathan, M. (1991) Advanced Text Book on Food and Nutrition Volume II, Bangalore Printing and Publishing Company, Bangalore.

UNIT 9 FOOD FOR GROWTH AND REPAIR

Structure

9.0 OBJECTIVES

After reading this unit, you should be able to:

- describe the effect of processing and storage on food quality and how to prevent them;
- state safe limit of preservatives; and
- discuss the health foods.

9.1 INTRODUCTION

Each food, although contains a wide range of nutrients but serves as a major source of one or two main nutrients. Since each food has a different nutritional profile, a judicious use of different foods is desired to maintain good health. The health of an individual is influenced by the utilization of nutrients, called nutritional status. The application of knowledge of nutrition in selecting food, its combination, preparation, storage, physiological need, nutritional knowledge; all affects the overall nutrition of a person and the community.

Food occupies the first position in the hierarchical needs of man but ignorance of basic food facts is still widespread. Consequently, various forms of nutritional disorders results, that can be prevented by proper dietary counselling. There is no known nutritional deficiency disorder that cannot be prevented by appropriate dietary habits. Only the need is to lay adequate emphasis to this fact and to provide adequate nutritional information to all of us. Food-based approach is the only sustainable way to improve the nutritional status of all.

It is not only the foods but also the quality of foods which is of prime importance for us. Foods if not processed properly, may loose their nutritive properties. Even if stored under improper storage condition or handled carelessly, they may get contaminated with microorganisms. Hence, for proper storage of fresh produce to retain their freshness, nutritive value and acceptability, proper handling, transport and storage of fresh or processed products is of great importance.

9.2 IMPORTANCE OF FOOD FOR GROWTH AND SUSTENANCE

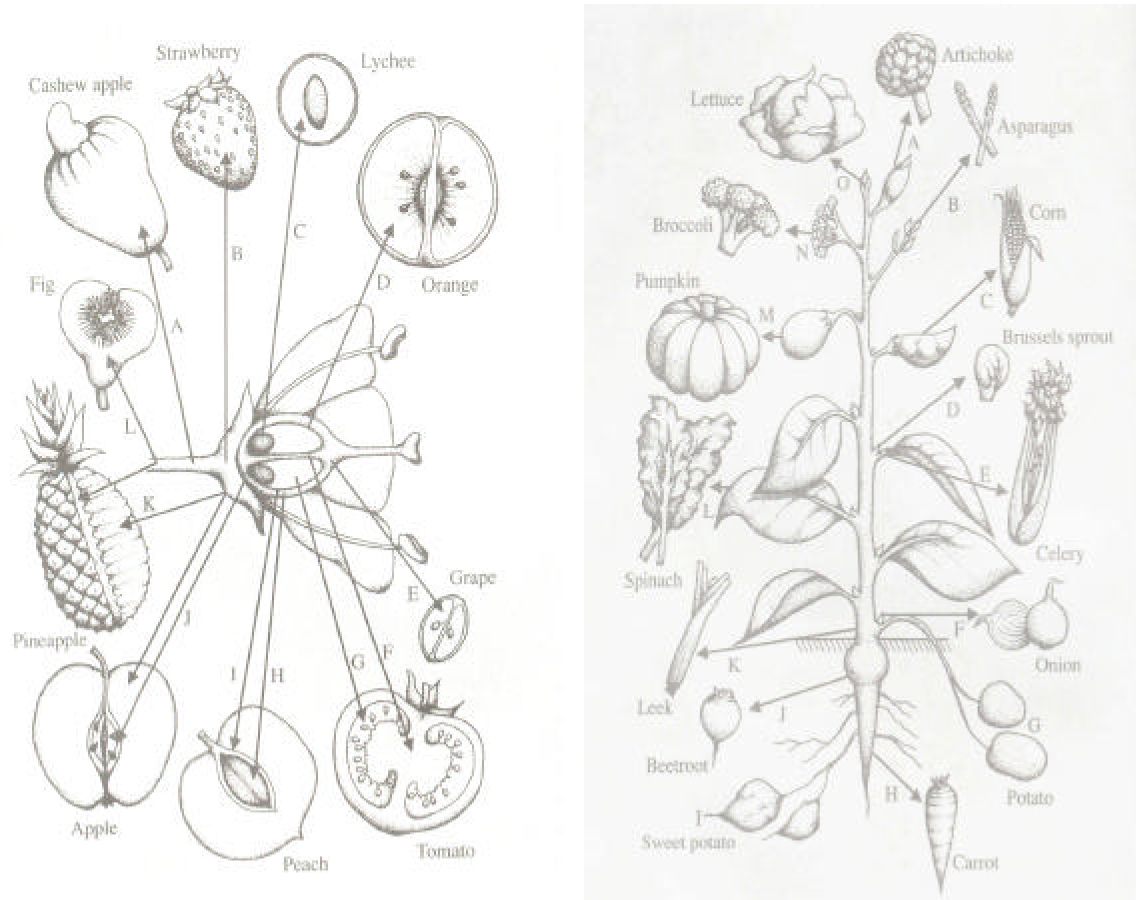
Food provides nourishment to our body. Food is absorbed by the body and used as an energy source. It is also used for growth and regulation. Further it also gives protection against diseases. In short, food is the raw material from which our bodies are made. Right kinds of food in right proportions can ensure good health, which may be evident in our appearance, efficiency and overall well being.

The foods which we use daily include rice, wheat, pulses, vegetables, fruits, milk, eggs, meat, fish, sugar, oils, etc. These foods are made up of a number of chemical substances called nutrients. According to their chemical structure, these nutrients can be classified as carbohydrates, proteins, fats, vitamins, and minerals. Water and fibre are also essential component of foods. Carbohydrates comprise sugars, starches, fibre, and related materials and mainly provide energy to our body. Proteins are nitrogenous compounds and form major component of tissue in our body. Fats provide energy and fatty acids to our body. Vitamins and minerals are required for metabolism and play a protective role in our body. In short, nutrients are essential for each and every voluntary or involuntary activity of the body and must be supplied by the diet.

9.3 FOOD STRUCTURE, TEXTURE, FLAVOUR, COLOUR, KEEPING QUALITY

9.3.1 Food Structure

Fruits and vegetables are important parts of our diet, they play a protective role as they supply the essential components to our body. Fruits and vegetables are living organisms and diverse in structure, in composition and in general physiology.



(a) **(b)**

Fig.9.1: a) Derivation of some fruits from plant tissue. The letters indicate the tissues that comprise a significant portion of the fruit illustrated as follows: A) pedical, cashew apple; B) receptacle, strawberry; C) aril, lychee; D) endodermal intralocular tissue, orange; E) pericarp, grape; F) septum, tomato; G) placental intralocular tissue, tomato; H) mesocarp, peach; I) endocarp, peach; J) carpels, apple; K) accessory tissue, apple and pineapple; L) peduncle, pineapple and fig. b) Derivation of some vegetables from plant tissue. The letters indicate the principal origins of representative vegetables as follows: A) flower bud, artichoke; B) stem sprout, asparagus; C) seeds, corn; D) axillary bud, brussels sprout; E) petiole, celery; F) bulb (underground bud, onion; G) stem tuber, potato; H) swollen root tuber, sweet potato; J) swollen hypocotyls, beetroot; K) swollen leaf base, leek; L) leaf blade, spinach; M) fruit, pumpkin; N) swollen inflorescence, broccoli; O) main bud, lettuce.

In general, however, the ovule develops into seeds and the ovary into fruit. Normally three layers are differentiated in the ovary wall or pericarp, these being the outer exocarp or skin, the mesocarp, which may be fleshy, and the inner endocarp. The structural features of fruits and vegetables on the basis of their derivation are shown in Fig 2.1a & 2.1b.

9.3.2 Food Texture

Food texture is a combination of sensations derived from the lips, tongue, walls of the mouth, teeth, and even the ears and touch by hand. The texture of fruits and vegetables depends on the turgor of the living cells as well as on the occurrence of supporting tissues and the cohesiveness of the cells.

9.3.3 Food Flavour

Flavour is the subtle and complex perception that combines taste, smell, heat and cold, and texture. The substances mainly responsible for the flavours of foods are volatile compounds. These may be aliphatic esters, aldehydes or ketones which are present in fruit and other natural foods in very low concentration. Orange, lemon and grapefruit peels contain a number of flavanone glycosides. Terpenoids are major components of citrus oils and contribute to the flavour of citrus fruits. Certain volatile sulphur containing compounds possess powerful and distinctive odours which contribute to both the pleasant and unpleasant aroma of many foods e.g. onion, garlic, cauliflower, broccoli etc.

9.3.4 Food Colour

The characteristic colour of raw food is due to the pigments naturally present in it. The natural colours (pigments) in vegetables and fruits can be classified on the basis of chemical structure as carotenoids (yellow -orange), chlorophylls (green), flavonoids and anthocyanins (red, blue, and purple) and anthoxanthins (cream yellow). Animal foods contain myoglobin and hemoglobin.

Chlorophylls are present in plants and vegetables especially leafy vegetables such as cabbage and lettuce etc.

Carotenoids are present in many vegetables and fruits such as carrot, pumpkin, mango, orange etc. Some of the carotenoids have vitamin A activity.

Anthocyanins - These occur in many fruits and vegetables e.g. coloured grapes, red cabbage, cherries, strawberries, plums, apple and in many flowers.

Flavonoids - Flavones and anthoxanthins are responsible for the yellow-white or creamy white colour of potato and cauliflower. Flavonoids are usually more stable to heat and oxidation than the anthocyanins.

Anthoxanthins – present in some fruits and vegetables.

Poly-Phenols - These are colourless or yellow substances which turn brown when fruits and vegetables containing them, e.g. brinjal, bottle gourd, apple, are cut and exposed to air. *Xanthones* are a group of red and yellow pigments. One well-known member is mangiferin, which occur as a glucoside in mangoes.

Betalains – betalains are a group of red and yellow pigments found in red beet and to some extent in cactus fruits, pokeberries and a number of flowers

9.3.5 Keeping Quality

The quality of fresh fruit and vegetables is related to their appearance, colour, uniformity, taste, flavour, texture, aroma, nutritive value, chemical composition, defective marks on the skin, chemical residue, additives and any other parameter the consumer chooses to be acceptable on the basis of their experience and education. Harvesting of fruits and vegetables disturbs the normal life process. As the fruits and vegetables continue to respire after harvesting, they start losing their vitality, turgidity, colour, appearance and food value and thus overall quality of food during storage at room temperature. Maturity level at the time of harvesting, harvesting practices of fruits and vegetables, handling practices, moisture content of foods, storage temperature, humidity and other storage conditions (light, oxygen, etc.) affects the keeping quality of the food. Keeping quality or storage stability (to preserve the overall quality during storage) is measured under storage and handling conditions that are set up to stimulate or somewhat exceed the conditions the product is expected to encounter in normal distribution and use.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Describe the significance of food for us?

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2. What do you understand by food flavours? Explain in brief.

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3. List the colour pigments present in fruits and vegetables.

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9.4 DEGRADATION OF NUTRIENTS, COLOUR PIGMENTS AND MICROORGANISMS DURING THERMAL PROCESSING AND STORAGE

9.4.1 Effect of Thermal Processing on Nutrients, Colour Pigments and Microorganisms

Almost all foods except fruits and some of the vegetables (used for salads) are subject to some type of heat processing to make them palatable and digestible. Thermal processing has both beneficial and adverse affects i.e. loss of nutrients. The loss of nutrients depends upon the processing temperature, duration of heat treatment and type of nutrients.

Blanching is a process in which dipping of fruits and vegetables in boiling water or exposing to steam for a few minutes stops all enzymatic and biological activities prior to processing. Losses of nutrients due to blanching occur directly from leaching of water soluble vitamins into water used for processing. In blanched vegetables such as asparagus, green beans, peas, spinach, the retention of ascorbic acid (67-95%), niacin (83-94%), riboflavin (88-90%) and thiamine (85-92%) is variable.

Pasteurization destroys pathogenic microorganisms associated with food and increases the shelf life by decreasing the microbial population and inactivates some enzymes. Pasteurization affects the vitamin content to a greater extent than other nutrients, e.g. vitamin C and riboflavin are most sensitive whereas vitamin E and K are slightly affected. Thiamine undergoes 3-20% destruction and riboflavin reduces to about 5%. Niacin content increases by about 10%, probably because of the liberation of protein bound nicotinic acid. Ascorbic acid being most sensitive undergoes oxidation. About 8% loss of vitamin C takes place during pasteurization.

Canning

Heating of canned fruits, juices, soups, vegetables, meat, and meat products etc. to destroy food spoilage microorganisms and enzymes result in some undesirable changes in the nutritive value of food. During canning, denaturation of proteins may occur. Heat, metallic tins and light accelerate oxidative rancidity of fats/ oils. The rate of oxidation of fat is doubled for each degree increase in the temperature. Sugars and starches are degraded by prolonged heating at high temperature. Browning reactions takes place in sugars on heating. Canning of vegetables causes losses in nutrients such as vitamin C (33-90%), thiamine (16-83%), riboflavin (25-67%), niacin (0-75%), folic acid (35-84%) and vitamin A (0-84%).

Ionizing Radiations

Effects of irradiation on the nutritional quality of foods vary with doses. Higher doses result in more destruction of nutrients than lower doses. Irradiations produce molecular changes in starch, converting it into sugars. Lipids are very sensitive to radiations. Auto-oxidation of lipids increases peroxide value i.e. the number of peroxides increases leading to off-flavours. Losses of amino acids also occur. During irradiation most of thiamine is found to be lost whereas riboflavin is heat stable and retained upto 91%. Niacin and folic acid are extremely radio-resistant and are fully retained. Vitamin K is sensitive to radiation and is destroyed in significant quantity during irradiation.

Colour Pigments

Vegetables and fruits contribute a variety of colours to the diet. The plant pigments chlorophyll (green leafy vegetables), carotenoids (yellow-orange carrots), flavonoids (white potatoes) and anthocyanins (red beetroot) are present singly or in combination in plant foods. These may be affected by the method of food processing. The soluble pigment such as anthocyanins may leach in the cooking water and changes may occur due to the effect of heat and pH (Table 9.1).

Table 9.1: Effect of heating on colour pigments of plant foods

S. No.	Food source	Name of pigments	Colour	Soluble in	Effect of prolonged heating	In presence of	
						Acid	Alkali
1.	Rice Potato	Flavones Flavanols	White or yellowish red	Water	May darken	White	Yellow
2.	Beetroot	Anthocyanin	Red	Water	Little	Bright red	Reddish purple
3.	Leafy vegetables	Chlorophyll	Green	Fat	Olive green	Olive green	Intense green
4.	Carrot Mango Tomato	Carotene Xanthophyll Lycopene	Yellow - orange	Fat	May darken	No change	No change

9.4.2 Effect of Storage on Nutrients, Colour and Microorganisms

The quality of food deteriorates during storage due to action of microorganisms on them if not stored properly. Deterioration is usually noticed by the presence of rancid odour of fats (caused by oxidation of fats), fermented odour of fruit or fruit juices due to yeast growth, or appearance of mould growth on bread, roti, etc. Hence, proper storage of food and food products is very important to avoid the quantitative and qualitative losses.

Fresh fruits and vegetables continue to respire after they are harvested. Harvesting disturbs the normal life processes, and vegetables start losing their vitality, turgidity and food value. The harvested vegetables continue to respire during transport and storage. This involves the use of oxygen, the metabolism of cell food materials and the release of carbon dioxide, water and energy. Most of the energy is released in the form of heat.

Most of the fruits such as mango, banana, citrus, guava, grapes, papaya, etc. are prone to injuries which become avenues for fungi especially moulds which deteriorate the fruits. The fruit packaging material is infested with organisms, which also act as source of infection. Due to unhygienic practices, fruits are subjected to various diseases causing huge losses. The most common type of spoilage in fruits and vegetables are bacterial soft rot, gray mould rot, blue mould rot, black mould rot, pink mould rot, etc. Fungal spoilage of vegetables often results in water soaked mushy areas, while fungal rots of fleshy fruits like apple and peaches mostly show brown or cream coloured areas in which moulds grow in the tissue below the skin. Whereas bacterial soft rot is commonly spread among the vegetables which are not very acid and among the fruits which are not highly acid.

Sometimes normal changes occur in raw fruit juices at room temperature such as alcoholic fermentation (conversion of sugars to acid, alcohol and gases) by yeasts, which further cause an oxidation of alcohol and fruit acids yeasts and moulds growing on the surface when it is exposed to air. Mostly at temperatures above 32.2^0C to 35^0C lactobacilli would be likely to grow and form lactic acid and some volatile acids.

Vitamin C and thiamine may be lost if canned foods are stored at ambient temperature. At room temperature, there is discolouration of pigments present in vegetables such as anthocyanins, flavanols and flavones very rapidly because of the activity of enzymes. Roots and tubers can be stored in cool ventilated place to avoid sprouting. Storage temperature should be maintained between 3 and 10^0C. Green leafy vegetables after harvest start losing resulting in loss of moisture. These vegetables can be stored at low temperature in clean and dry plastic bags to prevent loss of moisture.

The most common deteriorative changes taking place in milk at room temperature are souring, decomposition of protein, rancidity or bitter taste, off flavour, colour changes etc.

Deteriorative changes in meat can take place in aerobic conditions, anaerobic conditions and also by bacteria, yeasts or moulds. The changes, which take place under anaerobic conditions, are changes in colour, oxidation of unsaturated fats, undesirable flavour, off odour, of taste, etc.

Fish gets spoiled easily because of the rapid autolysis by the fish enzymes. The fat in pork and poultry are more easily oxidized than others.

Eggs are more spoiled by bacteria than moulds. If not properly stored there is a loss of CO_2 gas through the egg shell, loss of moisture and increased air space, loss of moisture from white to yellow, loss of normal firmness of egg white, etc.

Foods when properly stored retain their freshness longer; have better nutritive value and acceptability. Therefore, for better storage and long shelf life, all food and food products should be stored in a proper place according to their requirement.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.

b) Compare your answers with those given at the end of the unit.

1. Mention the nutrients, which are sensitive to temperature and light.

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2. How temperature affects the colour pigments? Explain.

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3. Why do the quality of harvested fruits and vegetables deteriorate?

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4. Why do the fruits and vegetables spoil at room temperature?

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9.5 PERMITTED COLOURS

Food Colours

The acceptance of food depends to a large extent upon its attractive colour. The characteristic colour of raw food is due to the pigments naturally present in it. Sometimes, artificial colour is added during the preparation and processing of foods to make them more attractive.

List of Permissible Harmless Food Colours

i) Natural colouring matter that may be used:

According to Fruit Product Order, India (1955), the natural colouring matters, whether isolated from a natural source or synthesized, are permitted to be added to any food product. Some of these are carmine, carotene and carotenoids, chlorophyll, caramel, annatto, ratanjot, and saffron.

ii) Coal tar dyes which may be used:

No coal tar dyes or a mixture thereof except the following shall be used in fruit products:

Colour	Common name	Colour index (1956)	Chemical class
i. Red	Ponceau 4R Carmosine Fast Red E Amaranth Erythrosine	16255 14720 16045 16185 45430	Azo Azo Azo Azo Xanthene
ii. Yellow	Tartrazine Sunset Yellow FCF	19140 15985	Pyrazolone Azo
iii. Blue	Indigo Carmine Brilliant Blue FOF	73015 42090	Indigoid Triphenyl-methane
iv. Green	Green S Fast Green FOF	44090 42033	Triphenyl-methane Triphenyl-Methane

Dyes when used in fruit products shall be pure and free from all harmful impurities. The maximum limit of any permitted coal tar colours or mixture of permitted coal tar colours which may be added to any fruit products, shall not exceed 0.20 g per kg of the final products for consumption.

As per the 'Code of US Federal Regulations (1979); and Prevention of Food Adulteration Act (India), Acid Magenta II, Blue VRS, Brilliant Black, Red FB, Red 6B colours have been prohibited for use in the food products.

9.6 HEALTH FOOD, GREEN/ ORGANIC FOOD, TRADITIONAL FOODS, DESIGNER FOODS

9.6.1 Health Food

Health foods are those, which are nutritious, prevent diseases and maintain health. Health foods are also known as 'designer foods'. Such foods must possess characteristics like modified composition, limit the presence of certain potentially harmful components and possibility of including certain desirable ingredients either naturally or by addition. These include vegetable foods, whole grain cereals, food processed without chemical additives, foods grown on organic compost, 'magic' foods (honey, molasses, yoghurt, etc.), and so on.

9.6.2 Organic Foods

Organic foods refer to the foods (either plant or animal foods) that are grown organically. These are grown on soils enriched with compost and manure and without the use of chemical fertilizers, insecticides or pesticides. Organic foods are the need of the hour because these foods offer protection of future generations, prevent soil degradation and erosion, protect water and aquatic life, save energy, protect farmers and farm women, help small farmers, support a true and sustainable economy, promote biodiversity, produce better, tasty, pure and nutritious foods.

9.6.3 Traditional Foods

Traditional foods are different types of food preparations with varying shelf life. These foods had been invented to overcome the monotony in the diet of the people, modified and repetitively processed by human communities. Their composition and preparation were based on the Pak Sastra i.e. Science of cooking. Traditional food processing began when man ceased to be a food hunter. To start with, it was confined to primary processing of food grains. Gradually, primary processing spread to other foods, gathering variety, variegation and velocity. In regions of primitive agriculture, food manufacture and management, man is still engaged in simple food processing practices, passed down through generations of tradition.

Indian traditional foods based on cereals, legumes and fats or oil - both sweets and savories, are innumerable in number, with characteristic features reflecting the diverse socio-cultural environments in different parts of the country. In our country; a nation steeped in culture and tradition dating beyond 5000 BC, these heritage foods for which preparative guidelines passed on from generation to generation are still made by skilled mothers and grandmothers, though many of these products have attained commercial importance during last 20 – 30 years.

Amongst various traditional foods, cereals and pulses based products still occupy an important place in the diets of our people. Historically, legumes are the natural protein supplements to cereals in the Indian diets. ‘Khichari’ one of the traditional products prepared from rice and pulse to prove a good quality diet, was in practice long before nutritionists and food scientists understood the nutritional importance of mixing grains.

The important traditional foods which are still popular among Indian population can be broadly categorized as: processed grain products, dehydrated foods, pickles/chutneys/sauce/relishes, ground spice/spice mixture, fried food products, confections and sweet dishes, and dairy products. Some popular traditional foods prepared and served at homes, restaurants and public eating places (bus stops, railway stations) with subtle differences in blends and flavours but essentially Indian are listed in Table 2.2.

Table 2.2: Some characteristic traditional foods of India

Major raw material	Products
Cereals/legumes	Papads, Wadian, Vermicelli, Soji, fried snacks.
Milk	Malai, Khoa, Chhana, Paneer, Curd, Butter milk.
Milk and sugar/jaggery	Peda, Burfi, Rasagolla, Jamun, Sandesh, Kheer, Halwa
Gram flour, sugar/jaggery	Mysore Pak, jilebi, Laddu and Chikki
Fruits and vegetables	Pickles chutneys, Murabbas, Patha, candied fruits, Aamchur, Fruit leather, dried fruits, dehydrated vegetables and pickled vegetables.
Spices and condiment	Spice powder, Sambar and Rasam powders and Garam masala
Miscellaneous	Neera, toddy, arrack, feni, vinegar, jaggery, khandasari, Sugar, and honey.

9.6.4 Designer Foods

Designer foods are foods that naturally contain or are enriched with certain specific concentration and proportion of nutrients/ substances that are important to health and prevent certain diseases such as phytochemicals (prevent cancer). The term was first coined in 1989 by Dr. Herbert Pierson, The National Cancer Institute (U.S.). The designer foods are also called as medical foods, fortified foods, nutritional foods, neutraceutical foods, functional foods, indulgence foods, slow foods, premium foods, therapeutic foods and healthier foods. Such foods are most commonly conceived as health foods that have therapeutic or prophylactic characteristics. The term "designer food" is subjected to change based on nutritional labelling regulations, new developments, consumer perceptions and expectations. Therefore it can be said that designer food is an evolving concept meant for reducing or delaying the risk of diseases.

9.7 PACKAGING FOR SAFETY AND QUALITY

Packaging of fruits and vegetables is undertaken primarily to assemble the produce in convenient units for marketing and distribution. The package must be capable of (i) protecting the produce from the hazards of transport, (ii) preventing microbial and insect damage and (iii) minimizing physiological and biochemical changes.

The important consideration in selecting the packaging material are (i) the product itself, (ii) the system of production, (iii) the systems of storage, (iv) the systems of handling, (v) the system of transport, (vi) the systems of merchandising, (vii) the consumer attitude, (viii) requirement of recycling/ reuse/ disposal, etc.

The traditional types of food packaging are boxes, cartons, metal cans, glass bottles and jars whereas the new innovations in packaging are aseptic packaging, PET containers, microwaveable containers, controlled/ modified atmosphere packaging etc.

a) Packaging for fresh fruit and vegetables

Fresh produce contains 80-90 per cent of moisture or even more and equilibrate humidity as high as 98%. Under normal atmospheric conditions, they will dry rapidly (transpiration). This causes wilting and shriveling due to shrinkage of cells. The existing postharvest loss of fruits and vegetables could be considerably reduced by adopting improved packaging, handling and efficient system of transport. The fresh fruits and vegetables during postharvest phase continue all vital processes. The respiratory heat liberated by fruits and vegetables must be taken out from the pack in order to extend their storage life. For this purpose film thickness, ventilation in the packs plays a very important role.

Modified Atmosphere packaging (MAP)

Plastics play a great role in creation of modified atmospheric (MA) condition around the commodities when the fresh fruits and vegetables are packed in plastic film bags. MA condition was reported to reduce bitter pit reduction and better retention of vitamin C in apples. The acute problem of ripening of Suvernarekha mangoes during transit was solved by adopting the MAP technology. However, proper temperature management and postharvest handling practices are required for storing these mangoes for longer duration (30-40 days). Similarly by adopting MAP technology, Mallika and Amrapali varieties of mango fruit could be kept up to 25 days at low temperature. The technology was also successfully applied to enhance the storage life with better quality attributes in many other fruits and vegetables viz. guava, cauliflower etc.

Prepackaging is generally defined as packaging the produce in consumer size units either at producing center/ farm before transit or at terminal markets. Prepackaging protects the produce against the damage and excessive moisture loss, reduce transportation cost by eliminating unwanted and inedible portion of fruits and vegetables, reduces the shopping time of the consumer as the produce is graded before packaging.

b) Packaging for processed products

The packaging materials used for various food products are metal cans, glass bottles/ jars, rigid/ flexible plastic packaging materials etc. Products like fruit jams, jellies, pickles are packed in wide mouthed glass jars. Products like fruit, squashes, syrups, RTS beverages, carbonated beverages etc. are packed in glass bottles.

Packaging for dried or dehydrated products

Dehydrated vegetables absorb moisture; they require a moisture resistant pack. Smaller sized packs of dehydrated vegetables are packed in heat sealable laminates consisting of PE, aluminium foil and paper. Powdered dehydrated products like fruits juice powders, soups, and custard powders require protection against ingress of moisture, oxygen and loss of volatile flavours and colour. They are usually packed in heat sealable laminates containing a layer of Aluminium foil. Cabinet dried, sulphured or sulphited mango pieces could be stored for 6 months in 400 gauge PE pouches for making Amchur.

Packaging for accelerated freeze dried (AFD) foods

The light, porous and brittle nature of AFD foods renders them susceptible to mechanical damage that affects the reconstitution characteristics. So, AFD foods must be protected against physical breakdown, moisture and oxygen absorption. *Aluminium foil laminates* are the best suited. Glue and cartons with foil laminates secured to the walls by spot gluing are suitable for over-all protection of AFD foods.

Bulk packaging of base products like fruits pulp and other intermediate products in plastics laminated pouches is practiced widely amongst manufacturers and processors. A variety of the finished products of fruits and vegetables viz. tomato products, fruit syrups, carbonated drinks and dehydrated fruits and vegetables are packed in plastic containers/ pouches.

Aseptic packaging

Aseptic packaging refers to a technique in which the product and the containers are sterilized separately and packed in a completely aseptic environment till it comes out of the system. Aseptically packaged juices and puree can be distributed in parts where refrigeration is not common. In aseptically processed 'bag-in-box' packed guava and papaya puree, no loss of vitamin C and flavour was observed but loss in colour took place.

Vacuum packaging

Vacuum packaging is used when the foodstuffs is susceptible to deterioration in the presence of oxygen. The air from the container is removed after filling the container and before sealing. This packaging increases the shelf life and quality of the packed material.

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. List the permitted colours? What is maximum limit of colour in fruit product?

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2. Briefly describe the health foods.

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9.8 LET US SUM UP

Food is essential to provide nourishment to our body to perform various functions. The appearance, colour, flavour, texture, and all other food qualities affect acceptance of the fresh and processed products. As respiration continues after harvesting, fruits and vegetables lose their vitality, turgidity, colour, appearance and food value, and thus overall quality at room temperature. Improper handling and transport increase the qualitative and quantitative losses. Heating brings several changes in the soluble colour pigment of fruits and vegetables. In order to maintain the wholesomeness of the fresh and processed products, these should be handled properly, transport carefully, stored under appropriate conditions and processed following the standard practices.

The packaging of produce and products is important to protect the produce from the hazards of transport, prevent microbial and insect damages, minimize physiological and biochemical changes and for longer shelf life.

9.9 KEY WORDS

Blanching	:	dipping of fruits or vegetables in boiling water or exposing these to steam for a few minutes to kill enzymatic and biological activity prior to processing.
Canning	:	process of sealing of foodstuffs hermetically (air tight) in containers and sterilizing them by heat for long storage.
Degradation	:	loss of quality.
Denaturation	:	structural change in proteins due to effect of heat, light, change in pH etc.
Deterioration	:	includes adverse changes in organoleptic quality, nutritional value, food safety, asthetic appeal, colour, texture and flavour.
Growth	:	increase in the physical size.
Oxidation	:	change in a molecule, which involves gain of oxygen, removal of hydrogen or loss of electron.
Quality of fruits and Vegetables	:	often referring to particular flavour characteristics, appearance, size or levels of a particular type of damage.
Turgor	:	pressure of cell contents on the partially elastic wall of a cell, tending to produce rigidity. One of the best known forces affecting cell volume is osmosis.

9.10 ANSWER TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

Your answer should include the following points:

1. Any eatable items provide nutrients is food.

   Food contain different nutrients namely carbohydrates, proteins, fats, vitamins, and minerals to perform various functions. See sub-sec. 9.1 and 9.2.

2. Volatile compounds are responsible for food flavour.

   Flavour compounds present in different fruits and vegetables. See sub-sec. 9.3.3

3. Different colour pigments with examples. See sub-sec.9.3.4.

Check Your Progress Exercise 2

Your answer should include the following points:

1. Blanching causes loss of water soluble vitamins due to leaching.

   Pasteurization (<100^0 C) destroys some of vitamin C and Riboflavin.

   High temp. during canning destroys water soluble vitamins significantly.

   Effect of canning on protein and fat. See Sub-sec. 9.4.1.

2. Effect of heating on colour pigments of plant foods. See Sub-sec. 9.4.1.

3. Respiration continues after harvesting.

   Metabolic heat of fruits and vegetables, improper handling and storage conditions causes deterioration in quality. See sub-sec.9.4.2.

4. Room temperature is favourable for growth of microorganisms.

   Enzymatic activities in fresh produce are high at room temperature. See Sub-sec.9.4.2.

Check Your Progress Exercise 3

Your answer should include the following points:

1. List of permitted colours.
   Limit of colours in fruit product. See sub-sec. 9.5.

2. Definition and characteristic of health foods. See sub-sec. 9.7.1 & 9.7.4.

9.11 SOME USEFUL BOOKS

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4. Mudambi S.R. and Rajagopal M.V. (1982) Fundamental of Foods & Nutrition (Third Edition), Willey Eastern Limited, New Delhi.

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6. Rick Parker (2003) Introduction to Food Science, Delmar, Thomson Learning, Australia.

UNIT 12 QUALITY CHARACTERISTICS

Structure

12.0 OBJECTIVES

After reading this unit, you should be able to understand quality attributes:

- physical factors;
- appearance factors;
- textural factors;
- kinesthetic factors;
- chemical and microbiological characteristics;
- quality standards;
- quality evaluation;
- grading and certification; and
- adulteration of food- detection and prevention.

12.1 INTRODUCTION

Quality is combination of attributes, properties or characteristics that give a commodity value in term of human food. Quality is overall, consumer's satisfaction and value worth, which he is paying. It is necessary for the food industry to become quality conscious and move towards attaining the international quality standards. Following are the important component of quality.

1. Appearance
2. Texture or firmness
3. Flavour
4. Colour
5. Purity
6. Nutritional quality: Foods play a very significant role in human nutrition especially as source of carbohydrate, protein, fats, vitamins, minerals and dietary fibre.

Foods are often thought of as healthy and nutritive matter having no risk of food borne illness associated with their consumption. The probability of getting sick from eating raw or processed food should not exist. Preventing contamination of fresh and processed foods from human pathogens and dangerous levels of chemicals/pesticides residues is the best way to assure that foods are wholesome and safe for human consumption.

12.2 PHYSICAL FACTORS

The defects, disease and decay can impair quality of fresh horticultural commodities. Defects can originate before harvest as a result of damage by insects, diseases, birds and hail, chemical injuries, and various blemishes (scars, scabs, rusting, rind scrapping etc.). Post harvest defects include sprouting of potatoes, carrots, onions and garlic, rooting of onions and seed germination inside fruits such as tomatoes and peppers, presence of seed stems in cabbage and lettuce and floret opening in broccoli. Physical factors also include shrivelling and wilting, mechanical damage such as punctures, cuts, scratches, splits and crushing, skin abrasions, scuffing, deformation, compression, bruising, growth cracks in fruits and vegetables.

Temperature related defects (freezing, chilling, sunburn, sunscald) puffiness of tomatoes, blossom end rot of tomatoes, tip burn of lettuce, internal breakdown of stone fruits, water core of apples, black heart of potatoes are the physiological defects.

While most of these defects reduce post harvest quality of perishables. There are examples of defects that do not influence post harvest quality of fresh produce or which may be called as consumer-tolerable defects. These include healed frost damage, scars and scabs, healed insect stings, irregular shape, healed hail damage, sub-optimal colour uniformity, colour intensity variations etc. The presence of defects frequently lowers the grade of the produce, which are other wise of good quality.

Uncontrolled cold also will damage foods. If fruits and vegetables are allowed to freeze, they suffer discolouration, changes in texture, or cracked skins, leaving the food susceptible to attack by microorganism. Carefully controlled freezing on the other hand need not cause these defects. Fruits and vegetables after harvest, like other living systems, have optimum temperature requirements. When held 'at refrigeration temperatures of about 4°C, some are weakened or killed due to chill injury and deteriorative processes follow. The deterioration includes off-colour development, surface pitting, and various forms of decay. Bananas, lemons, squash, and tomatoes are examples of products that should be held at temperatures not lower than about 10°C for maximum quality retention

12.3 APPEARANCE FACTORS

The quality of a food may simply be judged from its appearance when it is placed in front of a consumer. For example, a slight turbidity or cloudiness in orange juice is acceptable but not in apple juice, which must be crystal clear. Thus the overall eye appeal of a product is more important than taste and odour, and may determine acceptance or rejection without a trial tasting. Appearance deserve much more considerations in determining quality of a food and it includes size (dimensions, weight, volume), shape (diameter, depth ratio, smoothness, compactness, uniformity), colour (uniformity, intensity), gloss (nature of surface wax) and different external and internal defects.

Physical factors are such as size, shape, freedom from defect/damaged surface, type and extent of damaged parts. The optical properties such as colour, gloss and transparency of fruits and vegetables and the consistency of the processed products are also appearance factors that are indicative of quality. The appearance factors are highly useful and practiced in quality evaluation of fruits and vegetables, as well as in processed products.

Colour increases the attractiveness of many fruits and vegetables and used as a maturity index as colour undergo many changes as a part of the ripening process. Unripe fruit is usually green and in many types of fruit, the green colour becomes lighter during ripening and maturation owing to breakdown of chlorophyll, for example in apples, grapes, papaya. This may reveal underlying yellow or red pigments. Peel and pulp often undergo different colour changes, as in apples and bananas, In some cases, fruit colour is a strong indicator of eating quality and shelf-life, for example, tomatoes and bananas. Size and shape of fruits and vegetables are of major interest to the grower as it is directly proportional to the yield and also very useful in grading and handling during processing and transportation.

Defects may be caused by: (a) deformities caused by unfavourable environmental conditions (b) insects and microorganisms (c) mechanical injury during handling, transportation and processing such as damage, bruising and crushing (d) specks and sediments (e) foreign material or any other harmful added substance.

12.4 TEXTUAL FACTORS

Texture include various factors such softness, hardness, firmness, juiciness, grittiness or chewiness, fibrousness, mealiness and stickiness felt by the consumer when he handles the food with fingers (hand feel) or with the tongue, teeth or palate (mouth feel). Any deviation from the expected texture is said to be a quality defect. The texture of foods changes due to aging, improper processing or storage. Fresh fruits and vegetables become soggy due to over-ripening. Texture is an important factor in deciding the consumer acceptance of a food. In fact, quality of a food is mainly judged by its freshness/ripeness/ maturity or proper processing. For example, crispness of potato chips, the firmness and crunchiness of apples, and juiciness of fruit such as melons, non-sticky are indicative of prime quality of the food.

12.5 KINESTHETIC FACTORS

These are the quality factors which are judged by hands feel, mouth feel, and judged by sense of touch and tells about, chewiness, softness, juiciness, fibrousness, grittiness, mealiness, stickiness of fresh and processed foods.

12.6 FLAVOUR FACTORS

Flavour is a complex of taste and aromatic components. Total flavour can rarely be assessed by the consumer prior to purchase but it is critical in the repeat purchase of a particular product or product cultivars. Key taste components in fresh produce are sweetness, acidity, astringency and bitterness. Sweetness of some fruit may increase dramatically during ripening due to conversions of starch into sugars, for example in apples, bananas, mangoes and pears. Aroma may be fragrant, acidic & burnt and can be determined to some extent before purchase by the consumer but it tends to be important as a positive factor only in highly aromatic products such as certain cultivars of melon or mangoes.

Evaluation of flavour factor is highly subjective and depends on the discriminating ability of the consumer as flavour includes the sense of smell as well as the sense of taste as experienced by a consumer. People differ in their sensitivity to different odours and tastes as much as in their preference for various types of foods. In addition, consumers are influenced to some extent on the appearance, colour and texture of the food while evaluating the flavour characteristics.

12.7 CHEMICAL AND MICROBIOLOGICAL CHARACTERISTICS

12.7.1 Chemical Characteristics

Lipid oxidation and non-enzymatic browning are two major chemical characteristics which, affect the quality of fruits and vegetables during processing and storage and lead to a deterioration in sensory qualities.

Lipid oxidation results in production of off flavour as well as loss of ascorbic acid. It is influenced by light, oxygen concentration, high temperature, sunlight and the presence of iron and copper, and water activity. Control of these factors can significantly reduce the extent of lipid oxidation in foods.

Non-enzymic browning is one of the major causes of quality deterioration and takes place during frying, cooking, storage of dried and concentrated foods. The non enzymic browning is caused by the reaction of amino acids and reducing sugars through Mallard reaction, leading to insoluble black brown pigments which , produce bitter taste and loss in nutrients.

There is some loss of colour in fruits and vegetable during maturation, ripening, storage and processing due the degradation of chlorophyll, anthocyanins and carotenoids by oxidation. For example, dehydrated green peas and beans packed in clear glass containers undergo photo-oxidation and loss of desirable colour occur.

More than 150 reddish water-soluble anthocyanin pigments are present in the plant kingdom. Some anthocyanins form complexes with metals such as Al, Fe, Cu and Sn. by chemical reaction. These complexes generally result in a change in the colour of the pigment (for example, red sour cherries react with tin to from a purple complex) and are therefore undesirable. Since metal packaging materials such as cans could be sources of these metals, they are usually coated with special organic linings to avoid these undesirable reactions.

The carotenoids are a group of mainly lipid soluble compounds responsible for many of the yellow and red colours of food products. The main cause of carotenoids degradation in foods is oxidation. The mechanism of oxidation in processed foods is complex and depends on many factors. The pigments may auto-oxidise by reaction with atmospheric oxygen due to light, heat and the presence of pro-and anti-oxidants.

Ascorbic acid is the most important vitamin in fruits and vegetables and its stability vary markedly as a function of environmental conditions such as pH , concentration of trace metal ions and oxygen because it is oxidized in the presence of oxygen.

12.7.2 Microbiological Characteristics

The microbial action is associated with the presence of bacteria, yeasts and moulds on vegetables and fruits resulting in deterioration of quality during normal processes of aging. The microbial attack on fruits and vegetable and their processed products usually alter the appearance, texture, colour, odour, flavour or slime formation. The appearance includes colour changes, visible growth of microorganisms, formation of pockets of gas and microbial growth especially that of moulds on the surface of food products. As some foods deteriorate, they become soft or mushy. Degradation of foods results in the formation of compounds that have unacceptable odours and flavours.

The most common microbial spoilages in fruits and vegetables are mildew, brown rot, soft rot, black rot, green rot, mould rot or souring and water soaked musky areas, brown or white patches. These spoilage of quality are caused by *Penicillium italicum, Aspergillus niger, Alternaria sp., Mucor sp., Byssochlamys fulva, Botryis cinerea, Rhizopus nigricans, and saprophytic* bacteria.. Dry rots often lead to darkening and discolouring, and hardening of the surface of vegetables and fruits.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Describe quality.

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2. What are the quality characteristics of foods?

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3. List the main chemical characteristics.

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4. What are the main spoilage in fruits and vegetables?

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12.8 QUALITY STANDARDS

Different standards are employed to control the quality of fresh and processed foods in the country. Food standards for ensuring the quality and safety of foods for human consumption have been formulated and enforced by law in India. Food standards have been also prescribed based on the International Codex Alimentarius with suitable modification to suit Indian conditions. Different quality standards are summarized below.

Different Quality Standards

Name of standard	Features
a) Legal standards	– Mandatory standard established by federal state or municipal agencies. – Set up by law or represented by appropriate act. – Concerned with freedom from adulteration and proper quality control measures i.e. insects, moulds, yeasts, pesticides, maximum limit of preservative and food without contamination.
b) Company standards	– Established by food industry. – Represent consumers image and become trademark of symbol of product quality. – Are used by private firms or supermarkets.
c) Industry standard	– Established by an organised group for any given commodity. – Become effective by pressure from market organization or specific commodity group where legal standards are not involved.
d) Consumer or grade standards	– Represent consumer's requirement of a grade/standard product. – Based on experience in use by the industry for consumers.

The different standards take into consideration intrinsic qualities of foods, nutritional aspects, hygienic values and consumer appeal. Some standards are voluntary in nature and some are mandatory.

12.8.1 Legal Standards

These are also called as Health Ministry (Government of India) standards and are mandatory in nature. They are prescribed to ensure minimum quality in the foods marketed and promulgated under the Prevention of Food Adulteration Act other Rules and Orders of Government of India which cover food items: beverages, starchy foods, spices and condiments, sweetening agents, edible fats, milk and milk products, common salt, fruit products, edible oils, cereal products, vanaspati, vinegar, sweets and confectionary, food colours, limits for preservatives, antioxidants, emulsifying and stabilizing agents, flavouring agents, pesticide residues.

Quality denotes the degree of excellence of a product. It is indicated in terms of grades, standards and specifications which are laid down by a competent authority in the country. It is an important consideration in marketing of a product. Consumers are concerned about the safety, nutritional quality, aesthetic value, convenience to use and cost of foods. An established system of quality control assures uniformity in standards and thereby ensures that each food stuff is what it possess to be and what its label declares, if there is one.

12.8.2 Market Standards

The market dictates some quality parameters in the food stuffs marketed. There can be more than one quality requirement for a particular commodity. The economic status and quality consciousness of the consumer influences the market standards and they are voluntary in nature. Examples are different, grades of fruits, vegetables, rice with more or less broken, pulses etc.

12.8.3 Industry Standards

These standards require special quality factors in the foods the consumer purchase. Wheat miller requires wheat with high milling yield. A baker will require a wheat flour with high percentage of gluten of good strength to obtain a good loaf of bread. Similarly fruit processing industry will require certain specific qualities in the fruits like colour, flavour when they are purchased.

12.9 QUALITY EVALUATION

The quality evaluation of fruits, vegetables, other foods and processed products gives useful information on nutritional and biochemical characteristics. Quality evaluation methods can be destructive or non-destructive. They include both objective (based on instrument readings) such as physical, chemical, or microbiological and subjective (based on human judgment, using hedonic scales) methods as in taste. Subjective methods are also called as sensory analysis.

The physical, chemical and microbiological analytical methods are considered to be objective. These methods are usually standard scientific tests, which, one should be in a position to reproduce with the same results by any trained technician. Physical measurements include product attributes such as; size, weight, colour, texture, headspace and even impurities such as filth and insects. Chemical methods are usually more complex and often require sophisticated instrumentation. Precise tests for moisture, total soluble solids, titratable acidity, vitamins, colour pigments, proteins, carbohydrates, ash, pectin and fiber have become standard practice. Microbiological methods are used to determine the presence of bacteria, moulds and yeasts. The details of some of the methods used in the quality evaluation are given below:

12.9.1 Appearance Quality

Appearance quality of fruits and vegetables is measured by size, shape, colour, gloss and presence physical defects.

Size: Dimension-measured with sizing rings, calipers. Weight-correlation is generally good between size and weight.

Shape: Ratio of dimensions – such as diameter/depth ratio used as indices of shape in fruits.

Colour: Uniformity and intensity-important appearance qualities. Visual matching- colour charts to match and describe colours of fruits and vegetables. Light ref1ectance is measured by Hunter Lab Colour Meters and Agtron E5W spectrophotometer. Light transmission meters are used to determine internal colour and various disorders (water core of apples and black heart of potatoes). Lovibond tintometer is also used to judge the colour and it has universal acceptance. Determination of pigments (chlorophylls carotenoids, carotene, lycopene, xanthophylls), and flavonoids (anthocyanins) is done by colourimetric procedures.

Gloss (bloom, finish): measured using a Gloss-meter or by visual evaluation.

Presence of defects (external and internal): Evaluated using a scoring system of 1 to 5 (1 = no symptoms, 2 = slight, 3 = moderate, 4 = severe, and 5 = extreme). Which may be expanded to a 1 to 7 or 1 to 9 hedonic scale.

12.9.2 Textural Quality

Yielding quality (firmness, softness): Hand-held testers - determine penetration force using testers such as the Magness-Taylor Pressure Tester and the Effegi penetrometer. Laboratory testing-fruit firmness is determined by Instron Universal Testing machine or Texture Analyser or by measuring fruit deformation using a Deformation Taster.

Fibrousness and toughness: Measured on by Instron or Texture Testing System a Fibrometer.

Succulence and juiciness: Measurement of water and extractable juice contents are the indicators of succulence and juiciness.

Sensory textural: Evaluate grittiness, crispness, mealiness, chewiness and oiliness.

12.9.3 Flavour Quality

Sweetness: Sugars are determined by colourimeteric methods. For quick measurement of glucose in field, is done by enzyme coated strips. Total soluble solids contents are (sweetness) are measured using refractometers.

Sourness (acidity): pH of juice is determined by pH meter or pH indicator paper. Total titratable acidity is determined by titrating the extracted juice with alkali to pH 8.1.

Saltiness: Salt is determined by chemical method. Saltiness can be measured subjectively by sensory evaluation.

Astringency: Determined by taste testing or measuring tannin contents.

Bitterness: Determined by taste testing or measurement of the glyco-alkaloids.

Aroma (odour): Determined by sensory panels in combination with identification of volatile components.

Sensory evaluation: Human subjects – judge and measure combined sensory characteristics (sweetness, astringency, bitterness, overall flavour intensity) of a commodity.

12.9.4 Nutritional Value

Various analytical methods are available for determination of total carbohydrates, dietary fibre, proteins, amino acids, lipids, fatty acids, vitamins, and minerals in fruits and vegetables.

Eating Quality Factors: These include sweetness, sourness, astringency, bitterness, aroma and off-flavours. Objective analytical determination of critical components must be coupled with subjective evaluations by a taste panel to yield useful and meaningful information about flavour quality of fresh fruits and vegetables.

12.9.5 Non Destructive Methods

Acoustic and vibration tests: The sound of a fruit as it is tapped sharply with a finger knuckle can change during maturation and ripening and this method is used by consumers while purchasing fruits. Melons are trapped to judge whether they are ready to be harvested.

Electrical properties: Electrical properties of the fruit change with the soundness or maturity or spoilage or physical damage of the fruit. It has been found that the capacitance of deteriorated cell increased while resistance decreased and therefore the measurements could be used to determine the freshness or age of the fruit. At 500 Hertz the dielectric constant of green and ripe peaches was 550 and 150 respectively.

Nuclear magnetic resonance (NMR): NMR is being used to find the maturity & quality of fruits and it is also correlated well to sugar content of bananas & apples, and oil content in avocado. It has been used to detect bruises on apples, peaches, pears and onions, pits in olives and prunes and insect damage in pears.

Near Infrared Reflectance (NIR): It has been studied to measure the internal qualities like sugars, acidity, soluble solids, nitrogen & calcium in apples, peaches, pineapples, mango and pear. It is used to find the fruit firmness & their storability in cold stores.

Sonic techniques: Based on the generation of resonating frequency that can be used to calculate internal resistance (hardness).

12.9.6 Summary of Methods of Determining Quality

Subjective*	– Include sense organs – Based on opinion of investigators – Past training experience of individual's power or perception – Statistical Analysis required to get meaningful results
Objective**	– Based on scientific tests – No human perception is involved
a) Physical method	– Size, texture, colour, consistency, headspace, fill and drained weight, vacuum, container, symmetry, defects, viscosity

b) Chemical methods	– Enzyme, moisture, fibre, pH, acidity, protein, specific gravity, fat/oil, carbohydrate, ash, mineral, vitamins, sugars, tannins, alcohols
c) Microbiological methods	– Mold, insect fragments, insect, excreta, foreign material – Differentiation between cell types/tissue/ microorganisms – Determination of microbial count spoilage detection in the fresh and processed products, microorganisms causing spoilage/ fermentation

**Subjective:* The human eye is used to evaluate colour.

***Objective:* An instrument is used to provide a special colour value based on the amount of light reflected-off the commodity surface or the light reflected through the commodity. e.g. Lovibond tintometer.

12.10 GRADING AND CERTIFICATION

The fruits, vegetables and other foods are graded according to size, shape, weight, colour and visible defects to obtain uniform quality and fetch good price for the fruits. This is done by hand or machines. Automatic grading machines are available in which vibrating screens or screens with various sized slots are used to separate different types of product. *Density grading* is carried out by using different concentration of brine for fruits. Grading for colour is carried out by an electronic colour-sensing device. Manual grading done by hands and is usually necessary to avoid losses or to keep losses within reasonable limits.

To ensures quality and purity, Government of India, has established different agencies like AGMARK, Indian Standard Institute to make grades of foods, vegetables & fruits and they are affixing their marks (Agmark, ISI) on the products. The quality *of* product is determined with reference to the size, variety, weight, colour, moisture and, fats content and other factors. The act defines the quality of most of the agricultural raw and processed products commodities into various grades depending upon the degree of purity in each case. The grades incorporated are grades 1, 2, 3 and 4 or special, good, fair and ordinary. The physical and chemical characteristics of products are kept in mind while formulating the Agmark specifications.

Grading of commodities like ghee, butter, vegetable oils, *atta*, spices and honey is voluntary. On the other hand, grading of spices, basmati rice, essential oils, onions, potatoes etc. that are meant for export, is compulsory under AGMARK to ensure quality. The grading of agricultural commodities has three main purposes to: (i) to protect the producers and consumer from exploitation. By knowing the quality and grade of his produce, he is in better bargaining position against the trader. (ii) serve as a means of describing the quality of the commodities to be purchased *or* sold by the buyers and sellers in the country and abroad. Which avoids the need for physical checking and handling at many points. (iii) protect the consumer by ensuring the quality of products he purchases.

Under Indian Standard Specification fruits and vegetables have three grades, super, fancy and commercial.

Super: The fruits and vegetables under this grade shall be of similar variety characters, fresh, firm, i.e. not withered or wilted, tender, succulent, well shaped, fairly smooth clean and well coloured which means that the commodity has a uniform good colour characteristics of the variety over practically the entire surface, well developed, uniform in size, free from injuries and damage by scars, insects, diseases or mechanical or other means.

Fancy: The fruits and vegetables under this grade shall be of similar variety characters, fresh, firm, tender, succulent, well shaped, fairly smooth clean and well coloured. And are free from, injuries, damage by disease, insects, mechanical or other means.

Commercial: The fruits and vegetables under this grade shall consists which do not conform to the requirements of either super or fancy grade, but the quality is fit for use of human consumption.

12.10.1 Certification

The Bureau of Indian Standards, (BIS) Act, 1986, operates a product certification scheme, including Food and Agriculture. The certification allows the licensees to use the popular ISI Mark, which has become synonymous with Quality products for the Indian markets.

The BIS certification is voluntary, and aims at providing quality, safety and dependability to the customer. All BIS certifications are carried out on Indian Standards, which have been found amenable to product certification. Presence of certification mark known as Standard Mark on a product is an assurance of conformity to the specifications. The conformity is ensured by regular surveillance of the licensee's performance by surprise inspections and testing of samples, drawn both from the factory and the market.

The Govt. of India on considerations of public health & safety, and mass consumption has enforced mandatory certifications of 135 products through Orders issued under various Acts. While the Bureau grants licenses only on application however the enforcement of compulsory certification is done by the notified authorities and the Bureau maintains a close vigil on the quality of goods certified through its surveillance operations.

The broad area of food and agriculture under certification are: processed fruits and vegetable products, spices and condiments, bakery, confectionery and nutritious supplements, dairy products, drinks and carbonated beverages, fish and fisheries products, food additives, food analysis and nutrition, food hygiene, food microbiology, food grains, livestock feeds, oils and oilseeds, pesticides residue analysis.

12.11 ADULTERATION OF FOOD – DETECTION AND PREVENTION

Food is consumed should be pure provide energy and nutrition and as such it should be wholesome and not have deleterious substances. The food adulteration implies that food lack certain standard of quality or purity and, is a great menace to public health, posing serious threat to the society.

Food adulteration is defined as the process by which the quality or the nature of a food product is adversely affected through the addition of a foreign or an inferior substance and the removal of a vital element, such as fat from milks and the addition of water to it. Adulteration of food may endanger health due to either addition of a deleterious substance or removal of a vital component. Adulteration may be intentional or unintentional. The intentional adulteration is a willful act intended to increase the margin of profit while the incidental contamination is usually due to ignorance, negligence or lack of proper checking facilities. Adulteration of food stuffs is commonly practiced in India as the consumers like to get maximum quantity for as low a price as possible. When the price of the food product is higher than the price, which the consumer is prepared to pay, seller is compelled to supply a food product of inferior quality, thus adulteration done.

12.11.1 Types of Adulterants

i) Intentional adulterants	*Substances added to food are:* sand, marble chips, stones, mud, other filth, talc, chalk powder, water, mineral oil, harmful colours.
ii) Incidental adulterants	They are pesticide residues, tin from can, droppings of rodent's larvae in foods.

We are eating foods daily laced with some toxic pesticides. Even the rodents and insects introduce into the food a high degree of filth in the form of excreta, bodily secretions and microorganisms responsible for food spoilage as well as its intoxication. The incidental poisoning can be prevented by the following:

- Regular 'market basket' surveys to warn people of dangerous build-up of toxins in food.
- Stepping up the integrated pest management programme to educate farmers about the judicious use of pesticides. No spraying should be done a week before harvest.
- Promoting the control of pests using their natural predators.
- Preventing industries from dumping poisonous effluents.
- Considering health costs while deciding pesticide policy.
- Use of safer pesticides like synthetic pyrethroides or malathion.
- Thorough washing of foods to get rid of much of toxins.

12.11.2 Detection of Food Adulteration

Few important food adulterants and simple tests to detect adulteration of foods

Substance	Adulterant	Tests
1	**2**	**3**
Tur dal	*Lakh* dal or metanil	1. *Lakh dal is* irregular in shape and of lighter, colour than turdal 2. Add concentrated HCI to moisten dal. Yellow colour Will turn into magenta red if metanil yellow is present.

Dals	Kesari dal Clay, stones, gravels Lead chromate (yellow)	Add 50 ml of dilute HCI to dal and keep on simmering water for about 15 min. The development of pink colour indicates the presence of kesari dal. Visual examination detects these adulterants. Shake 5 g of dal with 5 ml of water and add a few drops of HCI. A pink colour shows the presence of colour.
Bajra	Fungus	Immerse in saline water, fungi will come on top
Wheat, bajra and other food grains	Ergot (a fungus containing a poisonous substance) Dhatura seeds	a) Longer size purple black grains in bajra show the presence of ergots. b) Put some grains in a glass containing 20% salt solution. Ergot floats over the surface, while sound grains settle down. Dhatura seeds resemble chilly seeds with blackish brown colour which can be separated out by close examination
Tea leaves	Exhausted tea or black or bengal gram dal husk with colour	a) Tea leaves sprinkled on wet filter paper would immediately release added colour b) Spread the little slaked lime on white porcelain tile or glass plate. Sprinkling a little tea dust on the lime will show the presence of coal tar dye. In the case of genuine tea, there will be only a slight greenish yellow colour due to chlorophyll which appears after sometime.
Mustard seeds	Argemone seeds	Agremone seeds have no round structure, they are pointed and are mere blackish than mustard seeds.
Chilli powder	Saw-dust and red colour	Sprinkle on the surface of water. Saw-dust floats. Added colour will colour the water.
Edible oils	Argemone oil Mineral oil	Add concentrated nitric acid to the sample and shake carefully. Red to reddish brown colour in acid layer would indicate the presence of argemone oil. Take 2 ml of edible oil and add equal quantity of N/2 alcoholic potash. Heat in boiling water bath for 15 min and add 10 ml of water. Any turbidity shows the presence of mineral oil.

	Castor oil	Dissolve some oil in petroleum ether in a test tube and cool in ice salt mixture. Presence of turbidity within 5 min indicates the presence of castor oil.
Turmeric	Coloured saw dust, metanil yellow Starch	Take a teaspoon full of turmeric powder in a test tube. Add a few drops of concentrated HCI. There is instant appearance of violet colour which disappears on dilution with water. If the metanil yellow colour persists (an artificial dye) the presence of non- permitted coal tar is indicated. Add iodine solution to turmeric solution, it will turn violet if starch is present.
Coriander	Horse dung powder	Soak in water. Horse dung will float which can be easily detected.
Ghee or Butter	Vanaspati Mashed potatoes, sweet potato and other starches.	Take about one teaspoonful of melted ghee or butter with equal quantity of concentrated HCI in a test tube and add to it a pinch of cane sugar. Shake well for one minute and observe it after 5 min. Appearance of crimson colour in lower (acidic) layer shows the presence of 'vanaspati'. The presence of mashed potatoes and sweet potatoes in a sample of butter can easily be detected by adding a drop of tincture of iodine. The appearance of blue colour indicates the presence of mashed potato, sweet potato or other starches.
Black pepper	Dried seeds of papaya fruit Light berries	Papaya seeds can be separated out from pepper as they are shrunken, oval in shape and greenish brown or brownish black in colour. The suspected papaya seed in black pepper sample is distinguishable by its characteristic repulsive flavour quite distinct from the bite of black pepper. Light berries float on spirit.
Rice	Marble or other stones	Place a small quantity of rice on the palm of the hand and gradually immerse the same in water. The stone chips will sink.

Wheat flour (maida)	Atta from which maida suji has been extracted	When dough is prepared from resultant wheat flour, more water has to be used and chapattis prepared out of this will blow out. The normal taste of chapattis prepared out of wheat is somewhat sweetish whereas those prepared out of adulterated wheat flour will taste insipid.

12.11.3 Prevention of Food Adulteration

To safeguard the interest of the consumer, it is necessary to have a check and control over the quality of food marketed for human consumption.

In India "Prevention of Food Adulteration Act" was promulgated by the Government in 1954 and the Rules under this act were made in 1955. The act was intended to make provisions for the prevention of adulteration in food. The act empowers the government agencies to prevent this unsocial activity and safeguard the health of the people. The implementation of the Act/Rules is done at State/Union territory level whereas the Central Government may give such directions it may deem necessary regarding execution of the provisions in the Act/Rules. For this purpose, the 'Central Committee for Food Standards' was constituted with (a) members representing concerned ministries, (b) representatives of consumers, medical professionals, agricultural, commercial and industrial organizations and hotel industry, (c) representatives of State/Union territories and (d) Directors of the Central Food Laboratories and (e) Director General of Health Services. Four Central Food Laboratories and a number of state level laboratories were established for analysis of samples collected by the state level food inspectors.

Standards under PFA Act and Rules: The standards laid down under the PFA Act and Rules are minimum standards of purity and are based on the agricultural practices, climatic conditions prevailing, and economic conditions and nutritional status of the people in the country

The standards are mandatory in nature and by government laws food articles which do not conform to the standards are considered unfit for human consumption. The Act and Rules deal with preservatives, poisonous metals, naturally occurring toxic substances, anti-oxidants, emulsifying and stabilizing agents, flavouring agents, colouring matter and other food additives, insecticides and pesticides, solvent extracted oils and edible flours, non-alcoholic beverages, starchy foods, spices and condiments and their mixes, honey, jaggery, saccharin, coffee, tea and milk, milk products, edible oils, cereals, baked products, sweets and confectionary and a range of similar products. The Act and Rules deal with the administrative procedures to be followed for reporting, analysis, prosecution, presentation of cases in a court of law and punishment to be carried out.

The adulterated food articles are defined under the Act.

12.11.4 Prevention of Food Adulteration Tips to Consumer

Despite the advantages of modern technology, illness due to adulterated/ contaminated food is one of the leading causes of sickness or death. Food-borne diseases range from acute gastroenteritis to precancerous/cancerous stage. Consumers are therefore offered tips in ascertaining quality of food by quick and simple tests for detection of common adulterants in food.

- Read label before purchasing.
- Purchase food articles from licensed vendors and insist on Bill or Cash Memo.
- Prefer foods sold in packed containers even if the cost is higher.
- Prefer foods certified by Govt. agencies like Agmark, ISI certification mark and FPO
- Avoid coloured foods especially sweetmeats or sharbats or ice candy.
- Buy foods from reputed firms.
- Do not buy cut or exposed fruits or vegetables.
- Do not use containers or packages used for insecticide chemicals or non-edible items.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What do you understand about quality standard?

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2. How many types of adulterants are there and the Act to prevent adulteration?

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3. What is Agmark?

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4. What are the benefits of grading and certification?

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5. Name the method of quality evaluation?

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12.12 LET US SUM UP

Quality of food is a combination of attributes, properties or characteristics that give a commodity value in terms of human food. The important components of quality are: appearance, texture or firmness, flavour, colour, purity and nutritional quality. Food plays a very significant role in human nutrition especially as source of carbohydrate, protein, fats, vitamins, minerals and dietary fibre. Lipid oxidation and non-enzymatic browning in fruits and vegetable are two major chemical characteristics, which affect the quality of food during processing and storage. The microbiological characteristics are associated with the presence of bacteria, yeasts and moulds on foods resulting in deterioration of quality.

Different quality standards are formulated and enforced by Government of India to ensure food quality and safety for human consumption. The quality evaluation of fruits, vegetables, other foods and processed products gives useful information on nutritional and biochemical characteristics and can be determined by destructive or non-destructive methods. These include both objective such as physical, chemical, or microbiological methods and subjective such as taste. Food adulteration is defined as the process by which the quality or the nature of a food product is adversely affected through the addition of a foreign or an inferior substance and the removal of a vital element. Adulteration may be intentional or unintentional. In India "Prevention of Food Adulteration Act" was promulgated by the Government to make provisions for the prevention of adulteration in food by law.

The fruits, vegetables and other foods are graded according to size, shape, weight, colour and visible defects to obtain uniform quality which is done by hand or machines. Automatic grading machines are available. Grading for colour, an electronic colour-sensing device is used. To ensures quality and purity, Government of India, has established Agricultural Produce Grading and Marketing Act (Agmark), and Indian Standard Institute to make grades of foods, vegetables and fruits & they are affixing the Agmark & ISI quality mark respectively on the products. The Bureau of Indian Standards, (BIS) Act, operates a product certification scheme, including Food and Agriculture. The certification allows the licensees to use the ISI Mark, which insure quality of products. The BIS certification is voluntary, and aims at providing quality, safety and dependability to the customer. All BIS certifications are carried out on Indian Standards, which have been found amenable to product certification.

12.13 KEY WORDS

Quality : It is a measure of the degree of excellence or degree of acceptability by the consumer.

Appearance : It include size, shape, colour, gloss and other visible defects of foods.

Texture : It include softness, hardness, firmness, juiceness, chewness, mealiness & stickiness, of the food commodity.

Flavour : It is a complex of taste and aroma.

Chemical characteristics : The lipid oxidation and non enzymatic browning are the chemical reactions of the rancidity and browning of foods respectively.

Microbiological characteristics : The microbiological characteristics are associated with the presence of bacteria, yeasts and moulds on foods resulting in deterioration of quality attributes

Quality standards : They are something that is set up and established by the authority for measuring quality.

Quality evaluation : The quality evaluation gives information on nutritional and biochemical characteristics of foods and determined by destructive or non-

		destructive methods which can be objective or subjective.
Adulteration	:	Food adulteration is the process by which the quality or the nature of a food product is adversely affected by the addition of a foreign or an inferior substance.
Grading	:	The food products are graded according to size, shape, weight, colour and visible defects to obtain uniform quality.
Certification	:	The certification allows the licensees to use the quality Mark to insure quality of products and certification may be voluntary or mandatory.
Hygiene	:	It involves all measures to ensure the safety, soundness and wholesomeness of food at all stages of production and processing.

12.14 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Your answer should include the following points:
   - Quality is combination of attributes, properties or characteristics that give a commodity value in term of human food.
   - Quality is overall, consumer's satisfaction and value worth.
   - Appearance, firmness, flavour, colour, purity, nutritional quality:
2. Your answer should include the following points:
   - Physical characteristics.
   - Chemical characteristics.
   - Nutritional characteristics.
3. Your answer should include the following points:
   - Lipid of oxidation.
   - Non-enzymatic browning.
   - Rancidity.
   - Maillard reaction.
4. Your answer should include the following points:
   - Mildew
   - Brown rot
   - Soft rot
   - Black rot
   - Green rot
   - Mould rot
   - Souring

Check Your Progress Exercise 2

1. Your answer should include the following points:
   - Different standards for ensuring the quality and safety of foods for human consumption have been formulated and enforced by law in India.
   - Legal standards.
   - Company standards.
   - Industry standards.
   - Consumer or grade standards.
2. Your answer should include the following points:
   - Intentional adulterants.
   - Incidental adulterants.
   - Prevention of Food Adulteration Act 1955.
3. Your answer should include the following points:
   - Derivative of Agricultural Marketing.
   - Agricultural Produce Act, 1937.
   - AGMARK products are free from adulteration.
4. Your answer should include the following points:
   - Uniform quality and fetch good price.
   - The grades are1, 2, 3, & 4.
   - Special, good, fair and ordinary grades.
   - Super, fancy & commercially grades.
   - BIS Act.
   - ISI mark.
5. Your answer should include the following points:
   - Physical, Chemical and Microbiological methods.
   - Objective and subjective methods.
   - Non-destructive methods.

12.15 SOME USEFUL BOOKS

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UNIT 13 DETERIORATIVE FACTORS AND THEIR CONTROL

Structure

13.0 OBJECTIVES

After reading this unit, you should be able to:

- know shelf life and dating of food;
- explain causes of food deterioration;
- know nutritional changes in food;
- describe food borne diseases;
- know food allergies and anti-microbial agents used in food;
- explain enzyme inactivation;
- describe different treatments to keep the food safe; and
- know hygiene and sanitation.

13.1 INTRODUCTION

Deterioration of food can be defined as any decay due to physical or chemical means or undesirable decomposition of constituents by excessive growth of microorganism. Food deterioration is manifested by the reduction in aroma, flavour, textural and nutritional values of foods. In extreme cases, the foods become totally unpalatable and is unfit for human consumption. Some microorganisms are also known to release toxins that may cause damage to health.

13.2 SHELF LIFE AND DATING OF FOODS

All foods have a time of the usefulness i.e. a time limit during which they can be consumed. Shelf life is the time required for a food product to reach to an unacceptable quality. The length of the shelf life of foods will depend on the type of food, processing method, packaging, and storage conditions. It is a practice to add some form of dating system to retail packages of foods so that consumers may have some indication of the shelf life or freshness of the products they buy. Food manufacturers put code dated on their products. The dates of manufacture ("pack date"). The date the product was displayed ("display date"), the date by which the product should be sold ("sell by date"), the last date of maximal quality ("best used by date"), and the date beyond which the product is no longer acceptable ("use by date" or expiry date").

One recent system for monitoring shelf life uses labels or tags on foods that respond to a combination of time and temperature to which the product has been exposed. These are called "time-temperature" indicators and are based on the principle that both time and temperature are important in the spoilage of foods.

13.3 CAUSES OF FOOD DETERIORATION

The major factors affecting food deterioration are: (1) growth and activities of microorganisms, principally bacteria, yeast, and moulds; (2) activities of food enzymes and other chemical reactions within food itself; (3) infestation by insects, parasites, and rodents; (4) inappropriate temperatures; (5) gain or loss of moisture; (6) oxygen (7) light (8) physical stress and (9) time.

These factors can be divided into biological, chemical and physical factors and often they do not operate in isolation. Bacteria, insects, and light, for example, can all be operating simultaneously to spoil food in the field or in a warehouse. Similarly, heat, moisture, and air simultaneously affect the multiplication and activities of bacteria and chemical activities of food enzymes. At any time, many forms of deterioration may take place, depending on the food and environmental conditions. The major types of spoilage of foods are microbiological, biochemical, physical and chemical.

13.3.1 Chemical Reactions

Chemical reactions take place in the presence of atmospheric oxygen and sunlight. Two major chemical changes, which occur during the processing, and storage of fruits and vegetables are lipid oxidation and non-enzymatic browning which deteriorate sensory quality, colour and flavour.

Lipid oxidation is influenced by light, local oxygen concentration, high temperature and the presence of iron and copper, and water activity. Control of these factors can significantly reduce the extent of lipid oxidation or rancidity in foods.

Non-enzymatic browning is one of the major causes of deterioration which takes place during frying, cooking, storage of dried and concentrated foods through Maillard reaction between reducing sugars and amino acids present in the foods and formed black brown insoluble pigments.

13.3.2 Biochemical Reactions

Different biochemical reactions in foods and plants tissues are catalysed by enzymes. They are responsible for certain undesirable or desirable changes in fruits, vegetables and other foods. Examples involving endogenous enzymes include: (a) the post-harvest senescence and spoilage of fruit and vegetables; (b) oxidation of phenols in plant tissues by phenolases leading to enzymic browning; (c) sugar – starch conversion in plant tissues by amylases; (d) post-harvest demethylation of pectic substances in plant tissues (leading to softening of plant tissues during ripening, and firming of plant tissues during processing).

Factors responsible for controlling enzymatic activities are: temperature, water activity, pH, chemicals which can inhibit or enhance enzyme activity.

Enzymatic spoilage is the greatest cause of food deterioration. If enzymatic reactions are uncontrolled, the off-odours, and off-colours may develop in foods. In fruit and vegetables, enzyme-induced oxidative breakdown of unsaturated fatty acids occurs extensively which, give characteristic aromas during ripening of fruits. Enzymatic browning take place in apples and potatoes during cutting and peeling and exposed to air, due to the oxidation of phenols by peroxidase and polyphenoloxidase.

Certain changes are produced by enzymes of foods and micro-organisms that contaminate the food. Ripening of banana is due to the enzymes present but after some time the fruit becomes too soft by microorganism enzymes and become unfit to eat. Enzymes convert starch into sugars, proteins into amino acids, and pectin into pectic acids and this change the constituents of food. Enzymes can act between 0^0 and 60^0C but 37^0C is optimum temperature. All enzymes are inactivated at 80^0C.

13.3.3 Physico – Chemical Reaction

Physico-chemical reactions are caused by freezing, burning, drying and bruising of fruits and vegetables during storage, handling and transportation, which result in food deteriorations.

Food processing or storage causes some deterioration in colour of fruits and vegetables due to the degradation of the chlorophyll resulting dull olive-brown colour. Dehydrated green peas and beans packed in glass containers undergo photo-oxidation and loss of desirable colour.

In addition to chlorophyll, anthocyanins and carotenoids also give colour to fresh and processed foods. Anthocyanins form complexes with metals which results in change in the colour of the pigment. Red sour cherries react with tin and form undesirable purple complex. Carotenoid degradation occurs in foods by oxidation in the presence oxygen, light and heat.

One major undesirable physical change in dried food powders is the absorption of moisture, which results in caking. In general, moisture absorption is associated with increased cohesiveness. Caking does not occur at water activities of less than about 0.4 at ambient temperature.

13.3.4 Microorganism: General Principles, Causes and Growth

Most significant deteriorative changes occur in foods due to microorganisms present in air, soil, water, on fruits, vegetables and foods. They are so small that they can only be seen through microscope. There are three types of microorganisms which cause spoilage: (1) Bacteria, (2) Yeasts (3) Moulds.

Bacteria

Bacteria are minute unicellular microorganisms. The growth of bacteria depends upon food , temperature, pH, moisture and oxygen. Bacteria are much more difficult to kill and are the most common causes of food spoilage. They are present in active form (vegetative stage) or resting form (spore stage). In vegetative stage, bacteria are destroyed at boiling temperature but spores require application of heat (100^0C) for a long time (six hours) or 30 min at 121^0C under 10 lbs pressure.

All forms of bacteria are sensitive to acids and can be killed easily in acidic pH at a temperature of boiling water. So foods with high acid content (all fruits, tomatoes, pickles etc.) are processed at $l00^0$C whereas low acid foods such as corn, peas, beans and all vegetables except tomatoes have to be processed at higher temperature (116^0C) in a steam pressure to kill bacteria. The temperature maintained and the length of time, the food is held vary with kind of foods. Moist heat resistant bacteria are present in the soil, hence, preparation and processing of root vegetables require special care. *Clostridium botulinum* causes spoilage in canned foods.

Bacteria enter through stomata and lenticels. The most common bacteria causing significant reductions in shelf life of fruits and vegetables is the soft rotting species of the genus *Erwinia*. Under suitable conditions they produce large quantities of extracellular enzymes which rapidly macerate the tissue which gives unpleasant off-odours

Most of the pathogens of fruits and vegetables will grow between 6 and 35^0C. Some (*B. cinerea)* will survive and even grow at low temperatures, 1^0C, on agricultural produce, whereas *Botryodiplodia theobromae* or *Aspergillus niger* cause losses in warm regions.

Each kind of bacteria has a definite range of food requirements. Level of moisture in food is important in preventing or allowing the bacterial growth in the food. Bacteria require more moisture than yeasts or moulds. Each bacteria has an optimal temperature at which it grows best. Temperature below and above the optimum adversely affects the growth of bacteria. pH determines the kind of bacteria that well grow on the food. Most bacteria grow best at neutral, pH, however, some bacteria also grow in acid or alkaline media.

On the basis of respiration bacteria are classified as:

- **Aerobic** : They require free oxygen for growth.
- **Anaerobic** : Do not require free oxygen for growth.
- **Facultative** : Grow either with or without free oxygen.

Yeasts

Fungi usually known as yeast are microscopic unicellular organisms, which are non-motile round or oval. Yeasts reproduce or multiply by a process of "budding". The bud when fully mature, breaks away from the mother cell and becomes independent and repeats the process of multiplication. Yeasts require less moisture and acidic pH to grow and do not grow in alkaline medium. Yeasts grow under moderate temperature (25-30 C) in solution containing sugar. Most of the yeasts usually do not grow in media containing more than 65% of sugar or 0.5% acetic acid. Heating at 60 ^{0}C for a few minutes is sufficient to destroy most species of yeasts. Boiling destroys yeast cells and spores effectively. Some yeast grow well in light sugar solution and acidic medium. Some yeasts are very useful in making bread, beer, wine, vinegar and many other fermented products. Yeasts are responsible for fermentation of fruits and fruit products. Yeasts are undesirable when they grow on fruits, juices, squashes, *sharbat*, honey etc. They spoil the appearance, taste, texture and wholesomeness of fruits and fruit products. During active fermentation, yeast can be recognized by formation of bubbles or foam on the surface of the product. Some of yeasts which grow on fruits are *Saccharomyces, Candida,* etc.

Moulds

Moulds are larger and more complex in structure than bacteria or yeast. Moulds are made up of mycelium and spores. They grow in a network of hair like fibres called mycelia and send up fruiting bodies that yield spores. A piece of orange left for a time becomes covered with a whitish or grayish cottony matter

They thrive best in closed, damp and dark situation and require adequate supply of warmth, moisture and air for growth. They are aerobic in nature and require less available moisture and can grow well at 25-30 C. Moulds prefer sugar containing substances like jam, jelly, preserves and other sweet based products. They can grow at wide range of pH (2 to 8.5) but majority grow well at acidic pH. Therefore, they grow nicely on pickles, juices etc. They can grow on many kind of foods especially when temperature, air and humidity are favourable. Their growth can be seen only on the surface of food. They not only consume nutrients present in food thereby lowering the food value but also produce odd by-products, which spoil the flavour, taste and texture of food hence change the quality contents of the entire products.

Majority of moulds are sensitive to heat and are destroyed at 60 C when heated for 30 minutes. Boiling quickly destroys both moulds and their spores. Some of common moulds are *Aspergillus Penicillium*, *Rhizopus* and *Heliminthosporium*.

Insect and Pests, Rodents

The main categories of foods subjects to insects and pest attack are fruits, vegetables, grains and their processed products, and dried fruits. The presence of insects and pests and their excreta in foods may render products consumable loss, in nutritional quality, production of off-flavours and acceleration of decay processes due to creation of higher temperatures and moisture levels and release of enzymes. The products of insect and pests activities such as webbing, clumped-together food particles and holes can also reduce the food values.

Warm humid environment promote insect growth, although most insects will not breed if the temperature exceeds about 35 C^0 or falls below 10 C^0. Many insects cannot reproduce satisfactorily unless the moisture content of their food is greater than 11%.

Rats and mice carry disease-producing organisms on their feet and/or in their feces and are known to harbour *Salmonella* associated with food-borne disease in humans. Rodents contaminate the food through defecation, urination or when walk over food or food contact surfaces. These animals also destroy intensively human’s foods. Rats and mice gnaw to reach sources of food and drink and to keep their teeth short. Their incisor teeth are so strong that rats have been known to gnaw through lead pipes and unhardened concrete, as well as sacks, wood and flexible packaging materials.

13.4 NUTRITIONAL CHANGES IN FOOD QUALITY

The four major factors, which bring nutritional changes in food quality, are light, oxygen, temperature and water activity. However, because of the diverse nature of the various nutrients as well as the chemical heterogeneity within each class of compounds and the complex interactions of the above variables, generalizations about nutrient degradation can not be made.

The major nutritional changes which occurred in foods are due to microbiological, enzymatic and chemical reactions.

Microbiological

- Growth or presence of toxicogenic and/or infective microorganisms.
- Growth of spoilage microorganism.

Enzymatic

- Hydrolytic reactions catalyzed by lipases, proteases, etc.
- Lipoxygenase activity.
- Enzymatic browning.

Chemical

- Oxidative rancidity.
- Oxidative and reductive discolouration.
- Non-enzymatic browning.
- Nutrient losses.

Physical

- Mass transfer, movement of low molecular weight components.
- Loss of crisp texture.
- Loss of flavours.
- Freeze-induced damaged.

One of the principal responsibilities of the food scientist is to preserve nutrients through all phases of food acquisition, processing, storage, and preparation. The key to doing this is a knowledge of the stability of nutrients under different conditions. Vitamin A is highly sensitive (i.e., unstable) to acid, air, light, and heat; on the other hand, vitamin C is stable in acid but is sensitive to alkalinity, air, light, and heat. Because of the instability of nutrients under various conditions and their water solubility, cooking losses of some essential nutrients may be greater than 75%. In modern food processing operations, however, losses seldom exceed 25%.

13.5 FOOD-BORNE DISEASE

Food-borne diseases cause food deterioration that may or may not alter a food's organoleptic properties but cause illness and disease to human beings after consumption. Food-borne diseases are classified as food infections or food intoxications. Food infections involve microorganisms present in the food at the time of consumption which then grow in the host and cause illness and disease. Food intoxications involve toxic substances produced in foods by microorganisms prior to consumption and cause disease upon ingestion. The toxin producer microorganisms need not to grow in the host to produce a disease or even be present in the food.

Staphylococcus aureus and *Clostridium botulinum* produce bacterial food poisoning by intoxication through the production of specific bacterial toxins. The toxin produced by *C. botulinum* is one of the most potent toxic substances known. Many bacteria can transmit food-borne infections capable of causing human disease. These include *Clostridium perfringens*, numerous members of the genus *Salmonella*, *Shigella dysenteriae, Vibrio parahaemolyticus, Streptococcus pyogens, Bacillus cereus, Campylobacter jejuni,* and other. A number of viral infection may also be contracted by man through contaminated food that has not been adequately processed or handled, including infectious hepatitis, poliomyelitis, and various respiratory and intestinal disorders. Over the last decade or so, several bacteria that had not been thought to be transmitted by food and cause human disease have found to do just that. Chief among these "newer" pathogens are *Aeromonas hydrophila*, *Yersinia enterocolitica*, *Listeria monocytogenes*, *Vibrio parahaemolyticus* and a particular type of *Escherichia coli* called 0157: H7 of particular importance is the recent discovery that some food-borne pathogenic bacteria can multiply at temperatures as low as 3.3^0C. This means that temperatures, which have been considered good for refrigerated storage, may not always keep food becoming a hazard.

Certain moulds produce mycotoxins, the best known being the aflatoxins by *Aspergillus flavus.* Aflatoxins are toxic to man and domestic animals. However, their carcinogenic properties are cause for much concern since aflatoxins can be produced in a wide range of cereals, legumes, nuts, and other products allowed to become mouldy. When such products occur in feeds, aflatoxins may subsequently be detected in the milk products of animals consuming the feed that is ultimately consumed by humans.

13.6 FOOD ALLERGIES

Food allergy may be defined as normal tissue reaction that may occur in some individuals after consuming a particular food or group of foods. Food allergens consists mostly of proteins, though some other chemical compounds present in foods may also produce allergic reaction.

Since the allergen is carried through all parts of the body, the allergies manifestations are many and varied. The skin and mucous membranes are particularly sensitive to the allergen. The sign and symptoms of allergy may include (i) Skin lesions, rash and eczema; (ii) Nausea, vomiting, diarrhoea and colitis; (iii) Headache, cold and asthma, and (iv) Redness, swelling, burning and itching of the eyes and irritation of the nasal mucous membrane. The allergy associated with consumption of orange and tomato juices is apparently due to traces of proteins present in the juice or to the peel oil.

The allergies are treated by drugs and also different types of diets are used in treatment of allergy (i) Synthetic diets, (ii) Elimination diets, and (iii) Restricted diets. Desensitization of the subject to the allergic food may also be carried out. Currently the only way to treat food allergies is to avoid the food that triggers allergic reactions.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What is shelf-life and dating of foods?

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2. Name the major causes of deterioration.

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3. What are nutritional changes in the food quality?

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4. Name the bacterial causal organism of food- borne infections.

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5. Food allergies consist of what bio molecules?

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13.7 ANTI-MICROBIAL AGENTS USED IN FOOD

Anti-microbial agents are the chemicals which inhibit the growth & development of bacteria, moulds and yeasts. They are weak acids work in the un-ionized form. They are not effective above their pKa values.

The use of anti-microbial agents depend on; **a**nti-microbial activity, pH of the food product, food composition, processing, and storage conditions, solubility, flavor, cost, marketing impact. The details of the most commonly used anti-microbial agents in food preservations are as follow:

13.7.1 Sulphite and Sulphur Dioxide

Sulphur dioxide and its derivatives have been extensively used in foods as a food preservative and anti-microbial agents. They act as an antioxidant, reducing & anti-microbial agents and prevents enzymatic, non-enzymatic reactions and microbial growth respectively. The common used forms are sulphur dioxide and sodium, potassium and calcium salts of sulphite, bisulfite or metabisulphite. The preservative action of sulphur dioxide as an anti-microbial agent in acid media, is due to undissociated compounds. It is like a biocidal and biostatic agent and is more active against bacteria than moulds and yeasts. It is more effective against Gram-negative bacteria.

13.7.2 Nitrite and Nitrate Salts

Nitrates and nitrites salts are inhibitors of toxic bacteria, involved in botulism, and considered as legal preservatives. Under regulations nitrites and nitrates are permitted as preservatives in cured meat and meat products including poultry at levels below 200 ppm. They also stabilize the colour after cooking and impart good flavour of lean meat without this the meat would be greeny brown. The use of nitrates and nitrites in the food industry is now subject to strict control.

13.7.3 Glycerol Esters

Glycerol esters show anti-microbial activity against Gram positive bacteria and yeasts. It is used as surface decontamination agents. It also inhibit *Clostridium botulinum* and widely applied in cured meats and refrigerated packaged fresh fish.

The inhibitory effect of the glyceride is due to the conduction of protons through the cell membrane, which effectively destroys the proton motive force that is needed for substrate transport. Death of cell arises due to the generation of holes in cell membranes.

13.7.4 Epoxides

Epoxides destroy all form of microorganisms, including spores and even viruses, but the mechanism of epoxides is poorly understood. They find applications in treating low moisture foods and to sterilize aseptic packaging materials. They are used in vapour state and after adequate exposure, most of residual unreacted epoxide is removed by flushing and evacuation.

13.7.5 p-Hydroxy Benzoate Alkyl Esters

The p-Hydroxy Benzoate Alkyl Esters (parabens) are widely used as anti-microbial agents in foods and pharmaceutical products particularly in baked foods, soft drinks, olives, pickles, jams and jellies and syrup. They are effective inhibitor of moulds and yeasts (0.5-0.1 %) but ineffective against bacteria, especially gram negative bacteria. In contrast to other *antimycotic* agents, the parabens are active at pH 7.0, and higher as they remain undissociated at these values.

Benzoates, sorbates, hydrogenperoxides, and propionates can also be used as anti-microbial agents.

13.8 ENZYME INACTIVATION

Some enzymes catalyze or initiate undesirable changes in colour, texture, flavour and nutrients of fruits and vegetables during storage and processing (Table 13.1). Inactivations of these enzymes prevent discoloration, improve flavour, soften tissues and loss of nutrients. Inactivation of enzymes is mainly done by blanching. Blanching is a mild treatment which expose plant tissues to steam or hot water, heating at 75-95 C for about 1 to 10 minutes, depending on the product requirements. At high temperature enzymatic proteins are denatured and make the enzymes inactive. If food processors did not blanch vegetables prior to freezing or dehydration, the natural enzymes would remain active even during frozen storage and destroy the product quality with time. Many vegetables which are not properly blanched develop a very noticeable off-odour and off-flavour.

Table 13.1: Enzymes responsible for quality deterioration in fruits and vegetables

Off-flavour development	• Lipoxygenase • Lipase • Protease
Texture changes	• Pectic enzymes • Cellulase
Colour changes	• Polyphenol oxidase • Chlorophyllase • Peroxidase (lesser extent) • Lipoxygenase*
Nutritional changes	• Ascorbic acid oxidase • Thiaminase

*hydroperoxides and radicals formed by lipid oxidation may destroy chlorophyll and carotenoids

In order to prevent undesirable changes in fruit texture, colour and flavour chemicals are used to inactivate enzymes as antioxidants. The inactivation of peroxidase is an indicator of effectiveness of blanching, and one could assume that all quality affecting enzymes had been destroyed.

13.9 TREATMENTS

The different treatments to prevent deterioration or spoilage of food should be performed so that it can be stored or preserved in fit conditions for future use. The classification of treatments of reducing deterioration is difficult because they do not act in isolation but take place together or one after the other. However the preservation procedures have two main characteristics:

- some of them are applied only to one or some categories of foods; others can be used across the board and thus a wider application (cold storage, freezing, drying/dehydration, sterilization, etc.);

- some guarantee food preservation on their own while others require combination with other procedures, either as principal or as auxiliary processes in order to assure preservation (for example smoking has to be preceded by salting).

13.9.1 Physical

It is better if the following physical treatments are kept in mind to control the spoilage.

- Heating,
- Cooling,
- Lowering of water content,
- Drying/dehydration,
- Concentration,
- Irradiation,

- Other physical means (high pressure, vacuum, inert gases),
- Salting.

13.9.2 Thermal

Heat or thermal processing includes heating and cooking, required to eliminate the potential of food borne illness. The simple act of cooking, frying, boiling or simply heating food prior to consumption are forms of food preservation. Cooked food itself can be held for several days provided it is protected from recontamination. Various methods in thermal processing include blanching, pasteurization and sterilization.

Blanching: Dipping of fruits & vegetables in boiling water or steam at temperatures around 75-95^{0}C for about 1 to 10 min, depending on the product requirements to inactivate enzymatic and biological activities. It is a necessary pre-treatment to achieve satisfactory quality in dehydrated, canned and frozen products. The process is required for reduction in enzyme activity otherwise undesirable changes in odour, flavour, colour, texture and nutritive value will occur during storage. It also helps in removal of intercellular gases to reduce the oxidative changes in food. Blanching may also result in some reduction in the microbial load and the texture may be improved.

Pasteurization: The food is heated to a temperature around 60 to 80 ^{0}C depending upon food product. The normal range is 65-75 ^{0}C at which nearly all the enzymes and vegetative microorganisms are inactivated. The heating may be done by steam, hot water, dry heat or electric currents, and then products are cooled promptly. Pasteurization does not kill all the microorganisms present in fruit juices. Some spores and spore forming bacteria like *Bacillus subtilis* can survive and multiply later.

Sterilization: Sterilization involves the use of heat at a temperature of 121°C (wet heat) for 15 min or longer to ensure total destruction of microorganisms including spores. The sterilized food must be placed in a container to prevent the entry of spoilage organisms. This is generally done with steam under pressure, as in a autoclave or commercial retort. Commercial pressure retorts operate at temperatures and for time intervals adequate to destroy large numbers of highly resistant bacterial spores within the canned food. Sterilization is not always necessary to kill all microorganisms but may be employed to destroy disease-producing organisms in the food.

13.9.3 Chemicals

Many chemicals will kill or inhibit the growth of specific microorganisms and prevent the deterioration of foods, but most of these are not permitted. A few that are permitted, in prescribed low levels in certain foods, include sodium chloride, acetic acid, sodium benzoate, sorbic acid, sodium, and calcium propionate, ethyl formate, and sulfur dioxide.

Sodium chloride: Common salt used in high concentration (15-20%) prevents the growth of microorganisms and increase the keeping quality of foods such as pickles. Salt at high concentration dehydrates microbial cells. Salt inhibits enzymatic browning and also acts as an antioxidant. Salt ionizes to yield chloride ions which, are harmful to the organisms and it also sensitizes the cell against carbon dioxide. Effectiveness of salt varies with its concentration and temperature.

Acetic acid: Acidic pH inhibits the growth of many microorganisms. Vinegar or acetic acid has germicidal and antiseptic properties and also checks aerobic and anaerobic fermentation. It is more effective against yeast and bacteria than molds. About 2% acetic acid prevents the spoilage of most products. It is used in preservation of pickles, sauces and chutney.

Citric acid: It is used in preservation of certain fruits and vegetables. It is added to jams, jellies, preserves and squashes. It increases the acidity and prevents mould growth.

Propionates: Sodium or calcium propionate is used most extensively in the prevention of mould growth. These are effective against moulds with little or no inhibition of most yeast and bacteria. Their effectiveness decreases with an increase in pH and optimal pH is 5 to 6, depending upon the food item. These are ideal preservatives for bread and baked foods to prevent contamination of loaves during slicing and/or wrapping.

Benzoic acid and its salt: Sodium benzoate as a salt of benzoic acid is used because it is more soluble than acid. It is benzoic acid molecule, which is germicidal. It is more effective against yeasts than molds. 0.06-0.10% of sodium benzoate preserves most fruit products (pH 3.5-4.0). In the long run, the benzoate may darken the products therefore, it is mostly used in coloured products of tomato, plum, watermelon, *jamun,* pomegranate and coloured grapes.

Sulphurous acid and its salts: Mostly potassium or sodium metabisulphite is used and gives characteristic sulpher dioxide smell. Sulphur dioxide retards oxidation, prevents discolouration or loss of flavour and vitamin C. It acts as a better preservative against bacterial fermentation and molds. It prevents enzymatic darkening of cut and peeled fruits and vegetables. But it cannot be used in products stored in tin cans because it causes pin holes in metals and forms incrustation of tin sulphide.

In dehydration of fruits and vegetables, burning of sulphur at levels 1000-3000 ppm preserves colour, as well as vitamin C, repels insects and destroys organisms. It bleaches colour of pigments and its use is restricted to products of fruit like mango, litchi, lime, orange, lemon, guava, etc.

Sorbic acid: It is an organic acid having anti-microbial properties and prevents moulds in preserves. The effectiveness of sorbic acid increases in acid media ($pH < 6.0$) and inhibit moulds, yeasts and some bacteria.

The sodium and potassium salts of sorbic acid are used as fungistatic agents for foods especially on surface and in wrapping materials. These are also used for the preservation of cheese, sweet pickles, etc. for the control of lactic acid fermentation.

Antibiotics: An antibiotic is a chemical produced by microorganism which, inhibit growth or destroy microorganisms. Antibiotics, subtelin and nisin are produced by *Bacillus subtilis and Streptococcus lactis* respectively and used to preserve asparagus, corn , peas, mushrooms, tomatoes and milk. They are more commonly used in canning of processed products and effectively reduce the thermal process requirements necessary to control the spoilage food products.

Chemicals preservations: Antioxidants, butylated hydroxy toluene (BHT) and butylated hydroxyanisole (BHA) are used as food preservative and they inhibit, retard or arrest the growth of microorganisms.

13.9.4 High Pressure Technology

High-pressure technology (HPT) is a new non-thermal process for preservation of fruits and vegetables. This technology is a combination of a high pressure, temperature and time. The process subjects food products to pressures between 50 and 700+ Mpa. High pressures kill microorganisms and inactivate enzymes without the use of heat that can damage the taste, texture, and nutritional value of the food. The mechanism does not promote the formation of new chemicals, "radiolytic" by-products, or free-radicals. By HPT, colour, nutrients, vitamins, and flavour are unchanged and undegraded. Moisture content of fruits and vegetables is very important because very little effect is obtained below 40%. Texture frequently can also be retained but will depend on the initial structure. The texture of high air content foods will likely be changed by HPT.

HPT is applied for the production of high quality shelf stable low acid foods. When combined with a moderate starting (pre-compression) temperatures of 70 to 95^0C, spoilage and pathogenic spores are destroyed within less than 1 to 2 minutes. Factors which are important to HPT are process pressure, process temperature (-20^0C to 121^0C), water activity, and pH.

Fruit based products such as jams, jellies, purees, sauces, fruit juices are processed in HPT at varying pressures 50-700 Mpa, temperature 5-20^0C and duration of 2-30 minutes and it improve gelation, faster sugar penetration and reduce the loss of flavour, texture, colour and aroma and nutrients. Inactivate pectinmethlylesterase, polypenoloxidase, peroxidase and lipoxygenase and pathogenic microorganism activity also. Other advantages include: reduced process times, minimal heat damage problems, retention of freshness, flavour, texture and colour and no loss of vitamin C

13.9.5 Cooling

Cooling means storage temperature above freezing and it ranges from 16C to –2.2 C. Cooling will preserve perishable fruits and vegetable for days or weeks depending upon the nature of the food by retarding microbial growth and enzyme reactions at low temperatures. The lower the temperature, the greater the retardation. Various types of cool storage are available.

Cool storage: The temperature in cool rooms where surplus food is stored is usually around 15C. Enzymatic & microbial changes in the foods are not prevented but slowed down considerably. Root crops, potatoes, onions, apples and similar foods can be stored for limited periods.

Cold store or chilling (0 to 5^0C): Chilling temperatures are obtained by mechanical refrigeration. Fruits, vegetables and their products can be preserved for a few days to many weeks. The best storage temperature for many foods is slightly above 0^0C but this varies with the product. Besides temperature, the relative humidity can affect the preservation of the food. Commercial cold storages (temp.2-5^0C; R.H 90-100%) with automatic control of temperature are used for storage of semi-perishable foods such as potatoes and apples and made their availability throughout the year. The growth of bacteria, yeasts, and moulds, and rate of all chemical reactions is slow at or below 10^0C, and becomes slower the colder it gets.

13.9.6 Freezing

At temperature below the freezing point of water (−18 to −40^{0}C), growth of microorganisms and enzyme activity are reduced to minimum. Most perishable foods can be preserved for several months if the temperature is brought down quickly and the food is kept at these temperatures. Foods can be quickly frozen in about 90 minutes or less. Quick frozen foods maintain their quality and freshness when they are thawed. Frozen foods should, always be kept at temperatures, below −5^{0}C. Properly frozen (–12 to –17C^0 by excluding air), juice retains its freshness, colour and aroma for a long time.

13.9.7 Microwave

Microwave energy produces heat in materials that absorb and heat foods in a unique fashion that largely eliminate temperature gradients between the surface and centre of food masses. Foods do not heat from the outside to the inside as with conventional heating since microwave penetration can generate heat throughout the food mass simultaneously. The microwaves can result in very rapid heating but requires special equipment, packaging materials, since microwaves will not pass through metal cans or metal foils. Microwave heating produce major differences in food appearance and other properties compared to conventional heating and reduces process time by 90%. Microwave heating increases the temperature of the interior water parts of the solid and has the following advantages: (1) A penetrating quality that leads to uniform drying. (2) Selective absorption by liquid water, which leads to uniform moisture profile within the particle. (3) Ease to control due to rapid response of such heating.

13.9.8 IQF (Individual Quick Freezing)

IQF generally refers to freezing of solid food/pieces/grains like green peas, cut beans, cauliflower pieces, meat, fish etc. While quick freezing relates mostly to liquid, pulpy or semi liquid products like fruit juices, mango/papaya concentrate and purees etc. There is no clumping together of pieces or grains. They remain individual separate pieces. Individual quick freezing have advantages:

- Smaller ice crystals are formed, hence, there is less mechanical destruction of intact cells of the food.
- More rapid prevention of microbial growth.
- More rapid slowing down of enzymatic action.

13.9.9 Ohmic Heating

Ohmic heating, has the advantage that a product containing liquid, solid, or solid-liquid mixtures can, be heated rapidly with a uniform thermal profile. This ensures significant quality retention in comparison to conventional thermal processing, where heat transfer to the interior resulting in significant quality loss. Ohmic heating eliminate bacterial spores. In ohmic heating, the food should possess at least a slight electrical conductivity. Since fats and oils do not conduct electricity, ohmic heating cannot be used in these products.

In transit, ohmic heating could be used to heat the food. The system is light weight, requires minimum space and an electrical power supply, and food packages that can be accommodated between electrodes. It is also suited to the available energy sources (electricity) in transit. This technology is used for simple heating of foods particularly which consists of particles suspended in liquids such as soups.

13.9.10 Drying and Dehydration

Both the terms "drying" and "dehydration" mean the removal of water. Drying is generally done under the influence of non-conventional energy sources like sun and wind. In sun drying, there is no temperature and humidity control. The hottest days are chosen so that the foods dry very fast, thus, preventing from getting spoiled due to souring. Quick removal of the moisture prevents the growth of the microorganisms. Dehydration means the removal of moisture by the application of artificial heat under controlled conditions temperature, humidity and airflow. In this process a single layer of fruit or vegetable, whole or slices is spread on trays, placed inside the dehydrator. The initial temperature of the dehydrator is usually 43°C which is gradually increased to 60-71 °C. Drying is economical and very useful process. Most of the foods contain enough moisture, which encourages action by their own enzymes and microorganisms growth.

Food dehydration cause minimum or ideally no other changes in the food properties and dried to final moisture of about 1-5%. Examples are dried milk and eggs, potatoes flakes, instant coffee, and orange juice crystals. Such products will have storage stability at room temperature for a year or longer. A major criterion of the quality of dehydrated foods is that when reconstituted by the addition of water they are virtually indistinguishable from the original food materials used in their preparation.

13.9.11 Irradiation

Irradiation is a non-thermal technology and involves the use of gamma rays, X-rays or electrons, and uses energy levels that assure no induction of radioactivity in the irradiated product. It retards ripening or senescence of raw fruits and vegetables, sprouting of potatoes. Irradiation will increase the shelf life of foods from 2-5 years. The product must be frozen to achieve stability without major off-flavours. A wide range of products can be preserved by irradiation but primarily it is used to preserve meats. Microorganisms are inactivated by different kinds of radiations. X-rays, microwaves, ultraviolet light, and ionizing radiations, differing in wavelength and energy have been used to preserve food. For all types of radiation, the doses required to sterilize foods, and inactivate enzymes, are generally excessive or borderline from the food quality view point, and all may cause flavour, colour, texture, or nutritional defects. Doses less than sterilizing appear more generally useful to extend storage life. Sub-sterilization doses can inactivate enzymes responsible for initiating vegetable sprouting.

Today, foods are irradiated with ionizing radiation, obtained from radioactive isotopes, which does not rise the temperature significantly and called "cold sterilization". Several foods such as spices, vegetables and fruits, and poultry have been approved for irradiation pasteurization at specific doses in India.

13.9.12 Curing

Curing is a formation of multilayered protective periderm on tuber vegetables after harvest when kept in heaps for 15 to 20 days at ambient conditions to prevent bruising during transport and handling, entry of microorganism and excessive loss of moisture. Plant tissues are covered with protective tissues, which serve to protect the plant from excessive water loss. The primary protective layer is the epidermis but if the plant organ undergoes secondary growth, a multilayered periderm may develop, for example, on apples or potatoes. The epidermis is covered with a waxy cuticle of cutin while the cell walls of periderm tissues generally become impregnated with suberin. Both cutin and suberin can reduce water losses from plant surfaces; however some water loss is inevitable.

13.9.13 Smoking

Smoke is used for preserving foods such as meats and fish. The preservative action generally comes from a combination of factors. Smoke contains preservative chemicals such as small amounts of formaldehyde and other materials from the burning of wood. In addition, smoke generally is associated with heat, which helps to kill microorganisms. This heat also tends to dry out the food, which further contributes to preservation. Smoking over a fire may be quite effective in preserving certain foods; on the other hand, today smoke may be added merely to flavour food, that is, without heat from burning. In meat products, smoke combined with other preservatives is used more for its flavour than for its preservative action.

13.10 HYGIENE AND SANITATION

'Hygiene' describes a system of sanitary principles for the preservation of health. Food hygiene is much more than cleanliness, it involves all measures to ensure the safety, soundness and wholesomeness of food at all stages from its production, processing, manufacturing, packaging, storage, distribution, display for sale and consumption. Food hygiene aims for the production, preparation processing and presentation of food, which is safe for consumer and had good keeping quality. It covers not only the proper handling of foodstuff but also cleanness and sanitization of all the utensils and apparatus used in preparation, premises of food processing unit, service and consumption to eliminate the contamination of food borne microorganism.

The food hygienic measures will involve:

- Protecting food from risk of contamination of any kind.
- Preventing any organisms multiplying to an extent which would expose consumers to risk, or result in premature decomposition of food.
- Destroying any harmful bacteria in the food through cooking or processing.

High standards of food hygiene are essential to prevent food poisoning, food-borne infections, food spoilage, loss of productivity, loss of business, food losses due to premature spoilage or damage, incorrect storage temperature or pest infestations and prosecutions for contraventions of food legislation. Hence, these standards of food must be achieved at a reasonable cost to ensure that the business remains profitable. For it, cost effective hygiene may be considered.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are anti-microbial agents and write their names?

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2. What is the enzyme inactivation and write the names of enzymes involved in colour changes of foods?

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3. Write different treatments to preserve the foods.

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4. Describe the benefits of hygiene and sanitation.

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13.11 LET US SUM UP

Deterioration of food is a decay or undesirable decomposition of constituents by excessive growth of microorganism or by other physical and chemical causes. The deterioration factors are: (1) growth and activities of microorganisms, principally bacteria, yeast, and moulds; (2) activities of food enzymes and other chemical reactions within food itself; (3) infestation by insects, parasites, and rodents; (4) inappropriate temperatures; (5) gain or loss of moisture; (6) oxygen (7) light (8) physical stress and (9) time. Biochemical reactions in foods are catalysed by enzymes and are responsible for undesirable or desirable changes. Nutritional changes occur in foods during storage and processing due to microbiological, enzymatic and chemical reactions. Food-borne diseases cause illness and infections to humans after consumption contaminated foods. Anti- microbial agents are the chemicals which inhibits the growth & development of bacteria, moulds and yeasts. At high temperature enzymatic proteins are denatured and make the enzymes inactive. Different treatments such as thermal, chemicals, high pressure technology, cooling, freezing, microwave, individual quick freezing, ohmic heating, drying and dehydration, irradiation and smoking are done to prevent deterioration or spoilage of food so that it can be stored or preserved in fit conditions for future use. Food hygiene involves all measures to ensure the safety, soundness and wholesomeness of food at all stages: production, processing, manufacturing, packaging, storage, distribution, display for sale and consumption.

13.12 KEY WORDS

Anti-microbial agents : Chemicals, which inhibits the growth and development of microorganisms.

Bacteria : They are minute unicellular microorganisms.

Biochemical reactions : Reactions catalysed by the enzymes in food and plant issues.

Blanching : Dipping of fruits and vegetables in boiling water or exposing these to steam for a few minutes to kill enzymatic and biological activity.

Cooling : Use of low temperature to retard chemical reaction and action of enzymes.

Drying and dehydration : Removal of water.

Enzyme inactivation : Stoppage of enzyme activity by denaturing them

Food-borne disease : Disease or infection caused to humans after eating spoiled food

Food deterioration : Decay or undesirable decomposition of food.

Freezing : At temperature below the freezing point of water (−18 to −40° C) growth of microorganism and enzymes activity are reduced to a minimum.

High pressure technology : It is a non-thermal process for preservation of foods.

Hygiene : A system of sanitary principles for preservation of health.

Individual quick freezing : Means individual freezing of solid food/ pieces.

Irradiation : Exposure to radiation-generally used to sterilize various foods by killing microorganisms.

Microorganisms : Very small living beings such as bacteria, yeast and fungi.

Pasteurization : The process of killing harmful organisms in a food by heating at controlled temperature below 100°C.

Sterilization : Heating at high temperature i.e. 100°C to kill microorganisms.

13.13 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Your answer should include the following points:
   - Shelf life is the time required for a food to reach at unacceptable stage.
   - The retail package of processed foods should have date of manufacture and expiry date to know the self-life.
2. Your answer should include the following points:
   - Microorganism, bacteria, yeast, moulds.
   - Activities of enzymes.
   - Chemical reactions.
   - Moisture, temperature, oxygen.
3. Your answer should include the following points:
   - Enzymatic: lipases, proteases, lipoxygenase, enzymic browning.
   - Chemical: Rancidity and non-enzymatic browning.
   - Physical: loss of texture and flavour.

4. Your answer should include the following points:
   - Clostridoium
   - Salmonella
   - Shigella
5. Your answer should include the following points:
   - Proteins
   - Chemicals

Check Your Progress Exercise 2

1. Your answer should include the following points
   - Anti-microbial agents are the chemicals which inhibits the growth & development of microorganism.
   - Weak acids and work when in the un-ionized form.
   - Sulphur dioxide and its derivatives, Nitrates and nitrites salts, Glycerol esters, Epoxides, p-Hydroxy Benzoate Alkyl Esters (parabens).
2. Your answer should include the following points:
   - Denaturation of enzymic proteins.
   - Blanching.
   - Polyphenoxidase and peroxidase.
3. Your answer should include the following points:
   - Thermal, ohemic heating.
   - Chemical.
   - Cooling, freezing, individual quick freezing.
   - Microwave, irradiation.
   - Smoking.
   - Drying.
4. Your answer should include the following points:
   - Reduction of microorganism contamination.
   - Prevention of food spoilage or decomposition.

13.14 SOME USEFUL BOOKS

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3. Potter, N.N. and Hotchkiss, J.H. (1996) Food Science (5th Ed). CBS publishers and Distributors, New Delhi.

4. Srivastava, R.P. and Kumar Sanjeev (2nd Edn) (1998) Fruit and vegetables preservation: Principles and Practices. International Books Distributing Co., Lucknow, India

5. Verma, L.R. and Joshi. V.K. (2000) Post-harvest Technology of fruits and vegetables. Indus Publishing Company, New Delhi.

6. Wills, R.B.H., Mc Glasson, W.B., D. Graham Lecture, T.H. and Hall, E.G. (1989) Post-harvest: An Introduction to the physiology and handling of fruits and vegetable. Chapman and Hall, Inc, New York.

UNIT 14 QUALITY ASSURANCE: REGULATION, CODES, GRADES AND STANDARDS

Structure

14.0 OBJECTIVES

After reading this unit, you should be able to answer:

- food safety issues;
- food adulteration, contamination and their detection;
- quality control;
- grades;
- standards;
- enforcement of food laws;
- testing of samples; and
- residue analysis

14.1 INTRODUCTION

Food industry plays an important role in the national economy. For a successful food processing sector, various aspects of total quality management such as quality control, quality system and quality assurance should function for total success. In today's global market, quality and food safety have a competitive edge of enterprises producing foods and providing services to reach the global market. As a member of World Trade organization (WTO), India is signatory to the Sanitary and Phytosanitary (SPS) agreement, and hence has to adopt for international standards, guidelines and recommendations issued by FAO/WHO, Codex Alimentarius Commissions, adoption of food safety standards. The Ministry of Food processing Industries is building awareness among, producers, processors and consumers about the advantages of foods quality, safety and assurance.

14.2 FOOD SAFETY ISSUES

The safety of foods is of utmost significance and has gained a worldwide attention. People have the right to eat the safe and suitable foods. Food borne illness and injuries can be fatal to humans and can damage trade and tourism. Food spoilage is wasteful, costly and can adversely affect trade and consumer confidence. Effective hygiene control, therefore, is vital to avoid the adverse affect on human health and economic consequences of food borne illness, injury and food spoilage. Everyone, including farmers, growers, manufacturers and processors, food handlers and consumers have a responsibility to assure that food is safe and suitable for consumption. These general principles lay a firm foundation for ensuring food hygiene and should be used in conjunction with specific code of hygienic practices. Consumers should also practice clean habits in handling, cooking and storage of food to ensure complete food safety.

In order to understand "food safety" we must first know the terms *safe, hazard,* and *risk.* "Safe" means that nothing harmful happens when we consume a food. A hazard is the capacity of a thing to cause harm. We should first identify hazards related to foods or food components and then estimate the size of the risk that the hazard will cause. It is important to note that all foods have some degree of risk and that no food is absolutely "safe." The important consideration becomes the size of the risk and how the size of the risk can be reduced without eliminating the food source. The goal of food safety is to reduce the size of risks to the lowest reasonable level without severe disruption of the food supply.

14.2.1 Specific Safety Issues

Specific food safety concerns differ markedly and include:

- Additives, colours and flavours.
- Antibiotics and other food additives.
- Fertilizers and other growing aids.
- Irradiation.
- Microbiological contamination.
- Naturally occurring food toxicants.
- Nutrition.
- Pesticides.
- Pollutants.

- Processing, packaging and labelling.
- Tampering.

Consumers are most concerned about pesticides and additives as both are linked to cancer and not to microbiological contaminations, however food industry is most concerned about the microbiological safety of its products. In addition, many quality control checks are made to ensure that foods are free of extraneous matter such as glass, machine fillings and insect parts. Many food industries adopt ‘Good Manufacturing Practice (GMP) and 'Hazard Analysis and Critical Control points (HACCP)’. Which assure that products manufactured under proper conditions and sanitation and hygiene will not have chance of contamination or error during processing.

14.3 FOOD ADULTERATION, CONTAMINATION AND THEIR DETECTION

14.3.1 Food Adulteration

Food adulteration is defined as the process by which the quality or the nature of a food product is adversely affected through the addition of a foreign or an inferior substance and the removal of a vital element. Adulteration of food may endanger health. Adulteration may be intentional or unintentional. The intentional adulteration is a willful act while the incidental adulteration is usually due to ignorance or lack of proper facilities.

Intentional adulterants: These adulterants are mixed with the food intentionally to increase the weight and quantity to make more money. Examples, sand, marble chips, stones, mud, other filth, talc, chalk powder, water, mineral oil and harmful colours.

Incidental adulterants: Pesticide residues, tin from can, droppings of rodents, larvae in foods. Some foods contain toxic pesticides, and the rodents & insects also introduce excreta, secretions and microorganisms responsible for food spoilage and intoxication.

14.3.2 Food Contamination

Food products are mostly contaminated with soil, air and water-borne microorganisms. Harvesting, processing, distribution and preparation generally contaminate the foods and food products which transmit certain food poisoning micro-organisms causing infections or intoxications or illness in humans. Food contaminations can be defined as the transference of any objectionable matter into or on the food. Following are 3 types of contaminations.

Contamination by microorganisms (bacteria, moulds or viruses): Generally occurs in raw foods such as vegetables grown on sewage, contaminated food premises, inadequate space and poor design. This type of contamination by microorganisms is the most serious and may result in food spoilage, food poisoning or even death.

Bacterial contamination is most significant as it results in large amount of spoilt food and large number of food poisoning cases. Bacteria are found everywhere: in soil, air, water, plants, animals, human and foods. Certain bacteria release toxins and cause death of persons consuming contaminated food. Some bacteria such as *Clostridium botulinum, Staphylococcus aureus,* *Salmonella bacteria* and *Bacillus cereus* are the common causes of food illness in humans.

Mould spores are found in atmosphere, on damp surfaces and on mouldy food. If food is stored at the wrong temperature at high humidity and in excess of the recommended shelf life, there are chances of food contamination.

Viruses like Hepatists A, Norwalk virus group and Rotavirus etc. are usually spread into food premises by food handlers who are carriers or on raw foods which have been grown in sewage polluted water and cause illness.

Yeasts grow best in the intermediate acid range, a pH of from 4.0 to 4.5. Food that is highly contaminated with yeasts will frequently have a fruity odour.

Physical contamination: Foreign bodies such as dust, dirt, stones etc. found in food may be brought into food premises with the raw materials or introduced during storage, preparation, service or display. Bolts, nuts, other pieces of metals, staples, cardboard string, polythene, rodent droppings, eggs and larvae of insects, cigarette buts, glass, wood splinters, paint or dust hair and fingernails, buttons and combs of persons handling the food are generally the sources of physical contaminations. Care should be taken that they do not contaminate the food.

Chemical contamination: Unwanted chemicals can enter the food during growth e.g. fertilizers, pesticides, environmental contaminants such as led or dioxins; during processing e.g. oil, cleaning chemicals; during transport as a result of spoilage or leakage and during sale etc.

14.3.3 Food Quality Assurance

Quality assurance includes the *planning* and *surveillance* of everything to do with quality throughout the company. Quality assurance seeks to generate confidence both within the organization and externally, among its customers, that their requirements will be fulfilled. Among the additional features acquired in the progress from quality control to quality assurance are the following:

- The definition of a quality policy and objectives;
- The development of a quality manual;
- Ensuring competency of personnel;
- Conducting periodic internal audits;
- The elimination of the root causes of the problems found; and
- Periodic reviews of the system by top management.

Above all, there is a shift in emphasis from mere detection to prevention of non-conformance. For introduction quality assurance system in the food industry good hygienic practices, a good agricultural practices, and good environmental practices for various industries should be adopted. The standards should become essential for introduction of quality assurance system in food industry in the form of potential hazards, GMP, HACCP, ISO:9000, Codex Alimentarius standards etc.

The Codex Alimentarius general principles of food hygiene are aimed to:

- identify the essential principles of food hygiene applicable throughout the food chain (production to consumption), to achieve that food is safe and suitable for human consumption;
- recommend a hazard analysis and critical control point (HACCP)- based approach to enhance food safety;
- indicate how to implement those principles; and provide a guidance for specific codes which may be needed for – sectors of the food chain; processes; or commodities; to amplify the hygiene requirements specific to those areas.

These principles are recommended to Governments, industry (including individual primary producers, manufacturers, processors, food service operators and retailers) and consumers alike.

14.3.4 Commercial Item Description

Commercial item description is defined under FPO standards (Govt. of India) for each processed food product which consists code number, whether concentrated or unconcentrated, sweetened or unsweetened, pasteurized or unpasteurized , made from ripe fresh and good quality fruits or vegetables, added water or not, and details of preservative, emulsifying, stabilizing agents i.e. name, quantity and quality (food grade). It also includes the quantity of total soluble solids, sugars, vitamins and addition of salt, colour etc. A label has to be fixed on the processed products mentioning date of manufacture, date of expiry, total weight of product, and nutritive composition the product i.e. total carbohydrate, fats, proteins, fibre, name of additive etc. Following are the few examples:

FRUIT JUICE means the unfermented and unconcentrated liquid expressed from sound, ripe fresh fruit and with or without:

a) sugar, dextrose, invert sugar, or liquid glucose, either singly or in combination;

b) water, peel-oil, fruit essences and flavour, common salt, ascorbic acid, citric acid, and preservatives.

The acidity of the finished product calculated as citric acid shall not be less than 4% in the case of pure lemon juice or pulp and not less than 5% in the case of pure lime juice but shall not exceed 3.5%t in the case of other juices.]

The total soluble solids for sweetened fruit juice (except tomato juice) shall not be less than 10%. It may also contain permitted emulsifying and stabilizing agents as prescribed in rule 61 C. It may also contain fumaric acid certified by BIS to the extent of 0.3%.

Tomato Juice means canned or bottled, unconcentrated, pasteurized juice expressed from tomatoes with a proportion of the pulp, expressed with or without the application of heat by any method that does not add water to juice, from whole, ripe tomatoes from which all stems and objectionable portions have been removed and with or without (a) salt (b) sugar, or dextrose, or both added in dry form (c) citric acid, malic acid or ascorbic acid. Provided that canned tomato juice may also contain extraneous permitted colour. The total soluble solids w/w shall be not less than 5 % ([free of salt). It may also contain permitted emulsifying and stabilizing agents as prescribed in rule 61-C. [It may also contain fumaric acid certified by BIS to the extent of 0.3 %.

Fruit Syrup means sweetened fruit juice containing, sugar, dextrose, invert sugar or liquid glucose either alone or combination, with or without:(a) water, peel-oil, fruit essences and flavours, common salt (b) citric acid, ascorbic acid.(c) permitted preservatives and colours. The total soluble solids w/w shall not be less than 65 %. The minimum percentage of fruit juice in the final product shall not be less than 25% w/w. It may also contain permitted emulsifying and stabilising agents as prescribed in rule 61-C.It may also contain fumaric acid (food grade) certified by BIS to the extent of 0.3 %.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are the food safety issues?

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2. Name the most common bacteria to cause food borne illness.

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3. What are good hygiene practices and standards for food safety?

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14.4 QUALITY CONTROL

Quality control (QC) is a means of detecting whether quality has been achieved and of taking action to correct any deficiencies. QC activities include:

- Establishing the specifications of the parameters to be controlled;
- Preparing quality plans for control;
- Performing checks or inspections;
- Diagnosing and taking action on the variations observed; and
- Checking that the variations have been corrected.

The fundamental purpose of a quality control program is to acquire dependable information on all the attributes of a product which affects its quality. Quality control ensures that raw materials meet set standards, processing methods should be performed as designed, finished products meet company standards and consumer confidence in the enterprise remains high. The basic functions of a quality control programme are:

- Physical and chemical evaluation of raw materials and processed products.
- Control of

  a) Raw materials, ingredients and packaging supplies.
  b) Processing parameters.
  c) Finished products.

- Microbiological analysis and control of 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 marketing standards established.

Quality control in fruits and vegetables begins in the field with the selection of proper time of harvest for maximum quality. Each subsequent step after harvest is to maintain quality and include the following step:

Operation	**Procedures**
Harvesting	Check maturity of commodity with respect to colours size, firmness etc.
Preparation for market	• Monitor various steps such as washing, sorting, waxing, sizing, post harvest treatments etc. • Check shipping containers for compliance with grade, size and weight regulations.
Cooling	Monitor product temperature at key points in the handling system, especially before and after cooling.
Transportation	Check transit vehicle for cleanliness, before loading, loading pattern, load immobilization etc.
Destination markets	Check quality and condition of the product and shipping containers at destination market.

Quality control personnel should devote full time and attention to their duties and make needed changes in the harvesting and handling operation as and when required to maintain the desired quality.

Quality control within a food manufacturing industry demands constant vigilance at all stages in processing, so that any necessary adjustments can be made at the appropriate time. The specific responsibilities of quality control is to ensure that the system used produces a standard product with acceptable quality in respect to nutrition, purity, wholesomeness and palatability. The specific responsibilities of quality control assigned to a department or to an individual include:

- Standardizing procedure for sampling and examining raw materials. Development of test procedures.
- Establishment and implementation of quality standards for fresh and processed products.
- Setting up preventive quality control methods for in-plant liaison between manufacturing section and test laboratories.
- Examination of finished products.
- Storage controls.
- Research and development into new products and their packaging.

Quality control leads to:

- Raw material control
- Process control
- Inspection of finished products
- Sensory evaluation or evaluation of the acceptability of the final product.
- Packaging
- Labelling and storage

14.4.1 Inspection

The objective of inspection is product conformance by screening out conforming products from nonconforming products, which is done by visual checks/ measurements; then testing and reporting. Under a simple inspection-based system, one or more characteristics of a product are examined, measured or tested, and compared with specifications to assess conformity. Products that do not conform to specifications are reworked, or regraded, or accepted with concessions, or rejected. This system is used for inspecting incoming goods, checking a product at intermediate stages, or inspecting a product ready for delivery to the customer. Using inspection to improve quality is too late, too costly and ineffective. In processing fruits and vegetables for export continuous inspection is applied. The inspection of raw materials should be carried out at the commencement of each processing run to ensure that only good quality fruits or vegetables of sufficient maturity are used for processing. Sampling checks of raw materials should be carried out frequently. Raw material and ingredients must be inspected and sorted to insure that they are clean, wholesome and fit for processing. Containers and carriers (such as trucks or railcars) should be inspected to assure that their condition has not contaminated raw ingredients

14.4.2 Lab Tests

The laboratory tests used in quality control are usually standard scientific tests for physical, chemical, microscopic and microbiological analysis. By adopting these tests one should be in a position to reproduce same results by any trained quality control technician. Physical tests include product characteristics such as size, weight, colour, texture and adulterants like, glass, stone, filth and insects. The processed products should be of prescribed size, weight, colour, texture etc and devoid of physical adulterants. The chemical tests for the estimations of moisture, protein, carbohydrates, minerals, fats, vitamins and fibre contents should be standards practice from the raw material and processed products for the prescribed quality. Microscopic and microbial tests are used to determine the presence of moulds, microbes and insect fragments or foreign materials, spoilage or disease microorganisms from the raw and finished products to obtain disease free foods. The tests assure that the final products are disease free, within the legal and marketing standards established.

14.4.3 Sanitation

The raw produce, processed foods, processing units and persons working in food processing units must be kept in good sanitary conditions to minimize the possibilities of contamination by microorganism, chemicals and physicals adulterants. The persons working in food units should not have any disease and must wear clean clothes, maintain a high degree of personal cleanliness and must wash or sanitize hands thoroughly before starting work and at any other time when the hands have become soiled. The food processing plant must be free from litter, waste or refuse; potential for foot-borne filth or breeding places for insects or microorganisms.

The processing units must be kept in good sanitary condition to minimize the possibility of contaminating foods or equipment that contact food. Pesticides, insecticides and rodenticides may be used to prevent contamination by pests, insects and rodents respectively. All utensils and equipment surfaces that contact food must be cleaned and sanitized before use to prevent food contamination. When utensils or equipment are used in a continuous production operation, they must be cleaned and sanitized on a predetermined schedule. The water which comes into contact with food or processing equipment must be safe and of good sanitary quality. The disposal of sewage water should be proper so that it must flow into sewage system or disposed of through other adequate means. Toilets and hand-washing facilities must be provided inside processing centres for workers. Raw materials must be washed or cleaned to remove soil and other contamination by sanitary quality water. Food processing equipment must be kept in a sanitary condition through frequent cleaning and, when necessary, sanitizing. If ice is used and comes in contact with food products, it must be made from potable water and be in a sanitary conditions.

14.4.4 TQM (Total Quality Management)

TQM requires the creation and continual improvement of processes, along with other quality assurance activities. Companies or organizations aspiring to quality management are characterized by the widespread application of the concept that everyone in the organization has customers and that their satisfaction should be enhanced; in this way, everyone is committed to continually improving their part of the operation.

a) TQM is a process designed to focus external/internal customer expectations preventing problem building, commitment to quality in the work force and promoting open decision-making.

b) TQM is an effective system for integrating quality development, quality maintenance, and quality improvement efforts of various groups in the organization so as to enable products and services at the most economical level, which allows customer satisfaction.

c) TQM is a building, housing the quality assurance system, quality consciousness of employees as the foundation, employee's involvement and commitment as the walls, the quality policy of the management as the roof.

d) TQM is an integrated organizational approach in delighting customers by meeting their expectations on a continuous basis through every one involved with the organization, working on continuous improvement in all products/services/processes along with proper problem solving methodology.

e) Meaning of Total Quality Management

Total	Every one associated with the company is involved in continuous improvement, in all functional areas, at all levels.
Quality	Customers expressed and implied requirements are met fully.
Management	Executives are fully committed Effective utilization of resources Decision in a planned way To maintain existing level of quality To improve existing level of quality.

14.4.5 Codex Alimentarius

The Codex Alimentarius is a collection of international standards for the safety and quality of foods as well as codes of good manufacturing practice and other guidelines to protect the health of the consumer and remove unfair practices in International trade. This is based on the recommendation of FAO and WHO, a worldwide conference for food standards and guidelines that would protect consumer's health and ensure international fare trade practices. Codex standards comprise standards for processed frozen fruits and vegetable, fruit juices, fats and oils, milk products, cereals and pulses, fish and poultry products, coca products and standards methods of analysis. Codex has also brought a list of more than 1000 food additives along with their permitted levels for use in different foods. The Codex general principles of food hygiene are aimed to: a) identify the essential principles of food hygiene applicable throughout the food chain to achieve the goal of ensuring that food is safe and suitable for human consumption. b) recommend a HACCP based approach as means to enhance food safety. c) indicate how to implements those principles and d) provide a guidance for specific codes which may be needed for – sectors of food chain; process; or commodities; to employ the hygiene requirements specific to those area.

14.4.6 HACCP (Hazard Analysis and Critical Control Point)

HACCP is a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product. Food safety systems based on the HACCP principles have been successfully applied in food processing plants, retail food stores, and food service operations.

Advantages

- Focus on identifying and preventing hazards from contaminated food is based on scientific principles.
- Permits more efficient and effective monitoring at government level, primarily because the record keeping allows investigators to see how well a firm is complying with food safety laws over a period rather than how well it is doing on any given day.
- Places responsibility for ensuring food safety appropriately on the food manufacturer or distributor.
- Helps food companies complete more effectively in the world market
- Reduces barriers to international trade.

The HACCP is based on 7 principles, which have been universally accepted by government agencies, trade associations and the food industry around the world. These include:

1. **Assessment of hazards:** Each unit operation should be evaluated to identify potential source of microbial, chemical and physical hazards, which may be introduced into the produce. Areas, which should be evaluated, are growing and harvesting operations, packing shed operations, packaging material and storage as well as distribution. This process is best accomplished by a team of both management and production personnel.

2. **Determine critical control points (CCP) to control the identified hazards:** The next step in developing a HACCP program is to draw a flow diagram for your specific operation and then determine where each of the identified hazards may be monitored. Each point that will be monitored to control specific hazard is now designed a critical control point.

3. **Establishment of CCO limits:** Once CCP have been identified, tolerance limits must be set to determine when corrective action needs to be taken. Tolerance must be observable and measurable.

4. **Established of CCP monitoring procedures:** How often monitoring will be done, how measurements will be taken and what documentations will be prepared must next be clearly defined.

5. **Corrective action when deviations from CCP limits occur:** When a deviation from the prescribed limits occurs corrective action must be taken to eliminate the potential contamination. All deviations and corrective actions must be noted in written form.

6. **HACCP record keeping system:** All paper work related to the HACCP system must be kept in an orderly and accessible manner. Records that should be kept include:

   - Production Records
   - Supplier audits
   - Pesticides usage and testing results
   - Irrigated water test results etc.
   - Harvesting Records:
   - Harvest dates and lot numbers
   - Total number of boxed harvested, etc.
   - All critical control point monitoring records
   - Storage and distribution records
   - Temperature monitoring
   - Truck cleanliness etc.

7. **Deviation file:** HACCP deviations and corrective actions taken.

   HACCP verification: Periodic HACCP plan review including review of CCP records, deviations and random sampling to verify that the HACCP program must be done to assure that HACCP program is functioning properly. This review should be done either on a monthly or quarterly basis.

14.5 GRADES

The quality of agricultural produce, cereals, spices, oil seeds, legumes, fruits and vegetables has criterion for the categorization into various grades depending upon the degree of purity in each case. The grades incorporated are grades 1,2,3 and 4 or special, good, fair and ordinary.

Grading of some commodities like vegetable oils, *atta,* spices and honey is voluntary. The grading of commodities like tobacco, walnuts, spices, basmati rice, essential oils, onions, potatoes meant for export is compulsory under government acts to ensures the quality of produces. Grading add extra cost and hence the graded products are priced slightly higher. The grading of agricultural commodities has three main purposes. Firstly, it protects the consumer from exploitation. By knowing the quality and grade of his produce, he is in better bargaining position against the trader. Secondly, it serves as a means of describing the quality of the commodities to be purchased or sold by the buyers and sellers all over the country and abroad. This establishes a common trade language and avoids the need for physical checking and handling at many points. Thirdly, it protects the consumer by ensuring the quality of products he purchases

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are the basic functions of quality control programme?

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2. Why inspection and grading are required in food processing?

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3. What is codex Alimentarius?

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4. Write the seven principles of HACCP.

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14.6 STANDARDS

Food standards for ensuring the quality and safety of raw and processed foods for human consumption have been formulated and enforced by law in India. Food standards have been also prescribed based on the International Codex Alimentarius with suitable modification to suit Indian conditions thus in India food processing and allied industries are governed by following different standards.

14.6.1 ISO (International Organization for Standardization) 9000 SERIES

ISO 9000 series are quality management and quality assurance standards. The principal of these standards is, 'if the system (input, process, output) through which the product is produced, is perfect then the product coming out of system will also be perfect'. This series of standards for quality assurances is now being adopted by most of the companies in India and abroad. More and more companies are in the queue for achieving this quality System Certificate. ISO 9000 series of standards are available which provide the guidelines for the establishment and management of quality system in the organization.

There are 4 basic models for classification of ISO 9000 Series:

ISO 9001 : Model for design, development, production, installation and servicing.

ISO 9002 : Model for production, installation and servicing.

ISO 9003 : Model for final inspection and testing.

ISO 9004 : Model for quality management and quality system element.

There are laid down guidelines on how to develop and follow systems as per the requirement of this series: The series covers the following major clauses**:** Management responsibilities, Quality systems, Contract review, Design control, Document control, Purchase, Purchaser supplied product, Product Identification and Traceability, Process control, Inspection and testing, Inspections and testing of measuring equipments control of nonconforming product, Corrective preventive action, Handling, storage, packaging and delivery: Quality records, Internal Quality audit, Training, service and statistical techniques

The main principal of achieving this certification is 'SAY what you Do and Do what you SAY'

14.6.2 Fruit Product Order (FPO)

Central Govt. formulated Fruit Product Order (1955 and 1961) which lays down statutory minimum standards in respect of the quality of various fruits, vegetables products and processing facilities. Packaging fruits and vegetables to standards below the minimum prescribed is an offence and punishable by law. Periodic inspection by inspectors is carried out to ensure conformity of standards by processors. Every manufacturer of fruit and vegetable products must obtain a license for manufacture and conform to the sanitary requirements and standard of quality specified. The inspectors are empowered to collect samples and inspect the factory and send the coded samples to Central

Laboratory. The order has laid down limits for the presence of poisonous elements. The act has laid down the standard specifications for the food products and food additives.

14.6.3 Meat Products Order (MPO)

This order regulates manufacture, quality and sale of meat and all meat products . Provisions are meant to control production, quality and distribution of raw and processed meat. This makes it illegal to transport meat unless it has been prepared and processed according to the provisions of the order and carries the mark of inspection. It provides means to (a) detect and destroy meat of diseased animals (b) ensure that the preparation and handling of meat and meat products is conducted in a clean and sanitary manner (c) Prevent the use of harmful substances in meat foods. (d) See that every piece of cut meat is inspected before sale to ensure its wholesomeness. The order also lays down the rules and conditions for procedure to be adopted for the selection of disease free animals, slaughterhouse practices and further treatment of the meat so as to maintain the meat in a wholesome manner, devoid of pathogens.

14.6.4 Cold Storage Order (CSO)

The cold storage order (CSO), 1980, promulgated under the Essential Commodities Act, 1955, has the objective of ensuring hygienic and proper refrigeration conditions in a cold store, regulating the growth of cold storage industry and rendering technical guidance for the scientific preservation of food stuffs in a cold store and prevent exploitation of farmers by cold storage owners. Agricultural Marketing Advisor to the Government of India is the licensing officer under this order.

14.6.5 PFA (Prevention of Food Adulteration Act and Rules in India)

Indian Government promulgated Prevention of Food Adulteration Act of 1954 to ensure that food articles sold to the customers are pure and wholesome. It also intended to prevent fraud or deception and encourages fair trade practices. The act was amended twice to plug the loopholes of escape and to ensure stringent punishment. The act prohibits the manufacture, sale and distribution of not only adulterated foods but also foods contaminated with toxicants and misbranded foods. A central food laboratory at Calcutta was established for the purpose of reporting on the suspected food products. A Central Committee for food standards has been constituted under the Act and has been charged with the function of advising the Central Government on matters relating to Food Standards. Provisions have been made in the Act for the appointment of Food Inspectors by the state Governments and their powers have been defined. The State Governments set up food testing laboratories and appoint Public Analysts with adequate staff to report on suspected foods. Standards have been laid under the PFA Act for various categories of food and according to PFA Act, a food shall be deemed to be adulterated if it does not meet the specified conditions mentioned in the Act.

14.6.6 AGMARK

The word ‘Agmark’ is a derivative of Agricultural Marketing. The Agmark standards were set up by the Government of India by introducing an Agricultural Produce Act in 1937. The Agmark seal ensures quality and purity. The quality and grade of product is determined with reference to the size, variety, weight, colour, moisture, fat content and other factors. The Act defines the quality of cereals, spices, oil seeds, butter, ghee, legumes and eggs and provides criterion for the categorization of commodities into various grades. The grades incorporated are grades 1,2,3 and 4 or special, good, fair and ordinary. The standards also specify the types of packaging to be used for different products. The physical and chemical characteristics of products are kept in mind while formulating the Agmark specifications. The Central Agmark Laboratory at Nagpur carrying out research and development work. The Certificate of Authorization is granted only to those in the trade having adequate experience and standing. The staff of the Directorate of Marketing and Inspection or of the State Government is generally present at the time of selection of goods, their processing, grading and packing before applying the appropriate AGMARK labels.

- Agmark products are free from adulteration and conform to the scientifically laid down principles of purity. It ensures consumer protection.
- Each batch of Agmark products is pre-tested for quality by quality control and trained chemist.
- Agmark products are always packed in food grade material never to be sold loose.
- Agmark products bear Agmark label or replica as an identification mark, date of manufacturing and expiry period.
- Free of cost replacement provided in the rules if Agmark products are found not conforming to the quality standards.
- They are not mandatory, any body can use them.

14.7 ENFORCEMENT OF FOOD LAWS

Food standards for ensuring the quality and safety of raw and processed foods for human consumption have been formulated and enforced by law in India. The laws and regulations exist to deal with food safety and consumer concerns about food contamination and adulteration, penalizing the seller of diseased, unwholesome and corrupted food products. The law defines foods, food preservatives and artificial colour, and ban the sale of food prepared under unsanitary conditions or containing any deleterious or unsafe substances. These also specify standards of quality for various classes of foods and outline the conditions under which a food would be regarded as adulterated or misbranded. Finally, there are statutory or legal obligations, which need to be fulfilled for safeguarding the health and well being of people and the establishment.

There are number of food laws being implemented by various Ministries/Departments of Indian Government. These are primarily meant for 1) Regulation of Specifications of Food, and 2) Regulation of Hygiene conditions of Processing and Manufacturing. The Government of India has also empowered several agencies and promulgated a number of acts and orders to ensure food safety. Agencies and institutes have also been created to lay down standards for quality of foods. The manner in which the food is processed and packed is also covered by a number of regulations. Some of these food quality assurance laws are voluntary and some are mandatory. The following are various food laws operating in India.

1. Prevention of Food Adulteration Act, 1954 and Rules 1955.
2. Agriculture Produce Act 1937 (AGMARK) Grading and Marketing.
3. Bureau of India Standards (BIS).
4. Environment Protection Act 1986 & Rules 1989.
5. Export Quality Control and Inspection Act, 1963.
6. Essential Commodities Act, 1955.
7. Insecticide Act, 1968.
8. Fruit Product Order, 1955.
9. Meat Food Product Order, 1973.
10. Solvent Extracted Oil, De oiled Meal and Edible Flour (control) order, 1967.
11. Milk and Milk Product Order, 1992.

PFA are enforced by the Department of Health. Under the law, slaughter houses, markets, factories, warehouses and other establishments involved in food trade may be inspected to ascertain that the raw materials as well as processing, packaging and storage facilities are sterile and ingredients meet the minimum standards prescribed by the law. Adulterated and misbranded products may be seized by inspectors, destroyed and legal action be taken depending upon the nature of the offence.

Food laws came into existence for a number of reasons:

i) To maintain the quality of food produced in the country;

ii) To prevent exploitation of the consumer by the sellers;

iii) To safeguard the health of the consumers;

iv) To establish criteria for quality of food products, since more and more foods were eaten in processed, rather than natural forms. This has resulted in the inability of the consumer to identify the quality of the contents that could be identified easily.

The legislation which is directly concerned with the protection of the health of consumers and the quality of food products marketed is the Prevention of Food Adulteration (PFA) which states that an article of food shall be deemed to be adulterated. The PFA Act, thus, lays down the guidelines for setting up standards for various food items like cereals and cereals products, pulses, ghee, etc. All processed items which, are mass-produced for public use, are expected to conform to these standards.

In addition to the mandatory acts and orders cited above, agencies such as Bureau of Indian Standards (BIS) and Directorate of Marketing and Inspection have also laid down quality standard for foods.

Operating quality systems as per quality system standards leads to doing right things on time, all the time and always to the customer's satisfaction

14.8 TESTING OF SAMPLING

The Food Health Authority (FHA) at State level is the Director of Public Health and Preventive Medicine. It is responsible for the good quality and standards of foods available to the consumers. Under FHA, the Local Health Authority appointed in each city of every State is responsible for testing of samples. The food inspector is appointed by the Central or State Government and they are trained in food inspection and sampling and have the powers to take sample of any food article from 1) any person selling such article 2) any person who is in the course of delivering or preparing to deliver such article to a purchaser or consignee 3) a consignee after delivering of any such article to him, and to send such samples for analysis to the Public Analyst (PA) of local area. When the Food Inspector wants to lift the suspected food, the shopkeeper must first be informed and there should be a witness present also. 150 g of sample is necessary to be sent for analysis but usually 600 g of sample is collected and sent to Central Food Laboratory Calcutta, and Central Food Technological Research Institute, Mysore. There is a recommended procedure to collect the sample and seal it in a bottle. The sealed bottle has a label on it in which the code number of the inspector, address of the shop, date and time of collection are written. When individuals doubt adulteration in foodstuffs they have to inform the Food Health Authority. Samples can be sent for analysis only after getting order from Food Health Authority. If the persons are found guilty of selling adulterated food, the persons involved can be convicted. A vendor found adulterating the food with ingredients injurious to health is liable for a much heavier sentence than a vendor involved in only mixing an inferior ingredient not injurious to health.

14.9 RESIDUE ANALYSIS

The foods require the absence of harmful substances like pesticides that are harmful for human health. The estimation of pesticides residues in foods is very important and the declaration of pesticides qualitatively or quantitatively has become inevitable for export and import. About 176 pesticides are listed which come into foods from their intentional or unintentional use on the crops. The maximum residue limits vary with the type of commodity. Use of many pesticides is restricted by law and the maximum residue limits commonly used pesticides are fixed by national (PFA in India) and international (Codex Alimentarius Commission) agencies.

Analysis of pesticides in foods is very cumbersome job and requires standards procedures and specific instruments. The basic steps for sampling and analysis of pesticides are given below:

Sampling ⟶ Sample preparation ⟶ Extraction of pesticides ⟶

Partitioning ⟶ Cleanup, Concentration of extract ⟶ Dilution with

appropriate solvent ⟶ Identification & estimation of pesticides

(GC, HPLC, Mass Spectrometer, GC-MS, UV-VIS Spectrometer, TLC etc.)

The sampling procedures and quantity for sampling varies with the commodity and type of sample. The sample should be drawn as uniform as possible from whole lot of produce.

Residue analysis consists of a chain of procedures. The analyst should be an experienced and competent in residue analysis. The laboratory requires an adequate range of reference standard pesticide of high purity. The range should cover all parent species and their metabolites. Chemical reagents, adsorbents and solvents should be high purity and not to interfere in the analysis. All glassware, reagents, solvents and water should be checked from contaminants before use. In a routine laboratory monitoring for compliance with national tolerances, standardized methods will be used and these should be validated periodically.

A number of instrumental procedures for estimation/confirmation are used in residue analysis. Gas chromatography (GC) is the commonly used instrument for qualitative and quantitative determination of pesticides residues. The specific columns and detectors are used for different groups of pesticides. Thin layer chromatography (TLC) is also used in some instances, confirmation of gas-chromatographic findings and identification most conveniently achieved by TLC. The advantages TLC are speed, low cost and applicability to heat sensitive materials but it has lower sensitivity than GC. High performance liquid chromatography (HPLC) can be used advantageously for the confirmation of residues initially found by gas chromatography or by other techniques and may be in certain circumstances the preferred quantitative technique. Mass spectrometers (MS) are generally sensitive at the nanogram level.

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.

b) Compare your answers with those given at the end of the unit.

1. What is ISO 9000 and write it's basic models?

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2. What is AGMARK and the advantages of AGMARK?

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3. Name the different Acts and Orders to enforce the quality of food in India.

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14.10 LET US SUM UP

The safety of foods is of utmost significance as people have the right to eat the safe and nutritious foods. Adulteration of food may be intentional or unintentional it endangers the health of consumers. Food products are mostly contaminated with microorganisms, (bacteria, moulds or viruses), and physical (dust, dirt, stones etc) & chemical (fertilizer, pesticides) contaminants. Quality assurance includes the *planning* and *surveillance* of everything to do with quality throughout the company and it generates confidence among consumers and customers. For introduction of quality assurance system in the food industry, good hygienic practices, good agricultural practices, and good environmental practices for various industries should be adopted. The standards should become essential for introduction of quality assurance system in food industry. Quality control ensures that raw materials meet set standards, processing methods perform as designed, finished products meet company standards and consumer confidence in the enterprise remains high. The specific responsibility of quality control is to ensure that the system used produces a standard product with acceptable quality in respect to nutrition, purity, wholesomeness and palatability. The objective of inspection is product conformance by screening out conforming products from nonconforming.

The raw produce, processed foods, processing units and persons working in food processing units must be kept in good sanitary conditions to minimize the possibilities of contamination by microorganism, chemicals and physicals adulterants. Total Quality Management requires the creation and continual improvement of processes, along with other quality assurance activities. The Codex Alimentarius is a collection of international standards and codes for the safety and quality of foods. HACCP is a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product. Food standards for ensuring the quality and safety of raw and processed foods for human consumption have been formulated and enforced by law in India. The laws and regulations exist to deal with food safety and consumer concerns about food contamination and adulteration, penalizing the seller of diseased, unwholesome and corrupted food products. The estimation of pesticides residues in foods is very important and the declaration of pesticides qualitatively or quantitatively has become inevitable for export and import foods. Identification & estimation of pesticides residues is done by GC, HPLC, Mass Spectrometer, GC-MS, UV-VIS Spectrometer, TLC etc.

14.11 KEY WORDS

Adulterated : The deliberate addition of inferior or cheaper material to a supposedly pure food product in order to stretch out supplies and increase profits.

Bacteria : Single celled microscopic organism.

Chemical sanitizers : Products used on equipment and utensils after washing and rinsing to reduce the number of disease – causing microbes to safe levels.

Contamination : The unintended pressure of harmful substances or conditions in food that can cause illness or injury to people who eat the infected food.

Critical control point (CCP) : means a point or procedure in a specific food system where loss of control may result in on unacceptable health risk.

Codex alimentarius : Is a collection of international standards and codes for the safety and quality of foods.

Disnifact : destroy harmful bacteria.

Food borne illness : An illness caused by consumption of a contaminated food.

Grade standards : Principally standards of quality to help producers, wholesalers, retailers, and consumer's in marketing and purchasing food products.

HACCP : called *hassip* is a management system in which food safety is addressed.

Juice : the aqueous liquid expressed or extracted from one or more fruits or vegetables or any concentrations of such liquids.

Sanitation : maintenance of conditions which are clean and promote good health.

14.12 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Your answer should include the following points:
   - Additives, colour and flavour.
   - Microbiological contamination.
   - Pesticides, fertilizers, food toxicants, pollutants etc.

2. Your answer should include the following points:
   - *Clostridium botulinum.*
   - *Salmonlla.*
3. Your answer should include the following points:
   - Good Manufacturing Practices
   - HACCP
   - Codex Alimanterius
   - ISO : 9000

Check Your Progress Exercise 2

1. Your answer should include the following points:
   - Physical and chemical evaluation of raw & processed material.
   - Control of raw material, processing parameter and finished products, storage and handling conditions.
   - Microbiological analysis.
2. Your answer should include the following points:
   - Product conformance.
   - Grading is done for purity and quality of product.
   - Fetch better price.
3. Your answer should include the following points:
   - Collection International standards and codex for quality and safety foods.
   - Recommended HACCP to enhance food safety.
   - Identify principles of food safety.
4. Your answer should include the following points:
   - Assessment of hazards.
   - Determine Critical Control Points (CCP).
   - Established of CCP limits.
   - Established of CCP Monitoring procedures.
   - HACCP record keeping system.
   - Deviation file.
   - HACCP verification.

Check Your Progress Exercise 3

1. Your answer should include the following points:
   - Quality management and quality assistance international standards.
   - ISO:9001, ISO:9002, ISO:9003, ISO:9004 for design, production, inspection and testing and quality management etc.

2. Your answer should include the following points:
   - Agricultural Produce Act, 1937.
   - Derivative of Agricultural Marketing.
   - Products are free from adulteration.
   - Pre-tested product quality and bear AGMARK seal.
3. Your answer should include the following points:
   - Prevention of Food Adulteration Act, 1954 and Rules 1955.
   - Agriculture Produce Act 1937 (AGMARK) Grading and Marketing.
   - Bureau of India Standards (BIS)
   - Fruit Product Order, 1955
   - Meat Food Product Order, 1973.

14.13 SOME USEFUL BOOKS

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4. Mc Swane, D., Rue, N. and Linton, R. (1995) Essential of Food Safety and Sanitation, Prentice Hall, New Jersey, USA.
5. Potter, N.N. and Hotchkiss, J. H. (1996) Food Science (5th Edition), CBC Publishers, New Delhi.
6. Sharma, R.N. (1997) Standards India.
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EXPERIMENT 1 EQUILIBRIUM MOISTURE CONTENT (EMC)

Structure

1.1 INTRODUCTION

Food materials tend to absorb or lose moisture according to the environmental conditions. They will absorb moisture when partial vapour pressure of the water inside the grain is less than the partial vapour pressure of water present in environment and *vice versa*. The moisture content at the time when equilibrium is achieved by absorbing or losing moisture for specific temperature and relative humidity conditions is known as "Equilibrium Moisture Content (EMC)". The EMC plays significant role in drying and storage of food grains as well as dried fruit and vegetable products.

Objective

After studying and performing this experiment, you should be able to:

- determine the EMC (w.b.) of foods.

1.2 EXPERIMENT

1.2.1 Principle

When a moist food product is placed in a gaseous atmosphere containing water vapour, heat and water vapour exchanges occur between the two phases. The food absorbs or loses water to the atmosphere until a state of thermodynamic equilibrium is reached. Temperature and pressure are then constant and equal in both phases. The moisture achieved in this condition is EMC. In this experiment constant temperature is achieved using incubators and constant water vapour pressure of environment (relative humidity) at particular temperature is achieved using saturated salt solutions. The study is done in closed chamber in order to achieve constant relative humidity.

1.2.2 Requirements (Equipment/Machinery/ Instrument and Chemicals/ Material)

- Hot air oven
- Moisture boxes
- Analytical balance (Least count 0.001 g)
- Desiccators

- Incubators
- Salts (NaCl, K_2CO_3, etc.), as per required humidity conditions

1.2.3 Procedure

- Set the incubator at a particular temperature.
- Place saturated salt solution, (particular salt which maintains a constant relative humidity at specific temperature), in the desiccators.

Table 1.1: Equilibrium relative humidities for some saturated salt solutions

Chemical	Relative humidity %		
	22·8ºC	30ºC	37.8ºC
Sodium chloride	75.5	75.2	75.1
Sodium nitrite	64.8	63.3	61.8
Sodium dichromate	54.1	52.0	50.0
Potassium carbonate	43.9	43.5	43.4
Magnesium chloride	32.9	32.4	31.9

- Accurately measure moisture content of the test sample by drying in an hot air oven. Then keep the sample in Petri dishes, transfer the Petri dishes into desiccators, close the lid and keep the desiccators inside the incubator.
- Accurately weigh samples after 15 days, daily and observe the increase or decrease in weight till it becomes constant.

1.2.4 Observations

Parameters	16 day	17 day	18 day	19 day	20 day
Weight of Petri dish + equilibrated sample (w3)					

Let weight of empty Petri dish was (w1), weight of Petri dish + sample was w2, initially. Based on moisture content of initial sample, the weight of water present in the sample was W4, and then EMC will be given as

$$\text{EMC} = \frac{\text{Weight of sample after equilibration} - \text{Dry matter content of sample}}{\text{Weight of sample after equilibration}} \times 100$$

$$= \frac{(\text{w3} - \text{w1}) - (\text{w2} - \text{w1} - \text{W4})}{(\text{w3} - \text{w1})} \times 100$$

1.2.5 Results

Calculate EMC using above formula. The results are always displayed along with temperature and relative humidity.

1.3 PRECAUTIONS

- Never touch the sample or Petri dishes with wet hands.
- The Petri dishes should be dried before placing the samples.
- Sample should be evenly distributed inside the moisture boxes in a single layer.
- The Petri dishes should not come in contact with salt solutions.

EXPERIMENT 2 BULK DENSITY

Structure

2.1 INTRODUCTION

It is the weight of the food material in a unit volume. It is of importance in the packaging, handling and other operations.

Objective

After studying this experiment, you should be able to:

- determine the bulk density of the food material.

2.2 EXPERIMENT

2.2.1 Principle

The finely ground material is filled in a container of known volume, and its weight is measured. The mass per unit volume is bulk density. It should be in kg per cubic meter.

2.2.2 Requirements (Equipment/Machinery/Instrument and Chemicals/ Material)

- Measuring cylinder (250 ml capacity)
- Analytical balance (Least count 0.001 g)

2.2.3 Procedure

- Weigh a 250 ml capacity measuring cylinder (Say W1).
- Fill the pre-weighed measuring cylinder with finely ground vegetable/fruit sample (30-mesh size) up to the 100 ml mark.
- Weigh the filled cylinder with sample (Say W2).
- Repeat above steps with two more lots of the same sample.

2.2.4 Observations

Parameters	Sample number		
	1	**2**	**3**
Weight of empty cylinder (W1), g			
Weight of cylinder + sample (W2), g			

2.2.5 Results

Calculate bulk density using the formula given below. Take the average of three values and report the results in kg/m^3.

$$\text{Bulk Density} = (W2 - W1) \times 10$$

2.3 PRECAUTIONS

- Filling of the cylinder up to 100 ml mark should be accurate.

EXPERIMENT 3 TRUE DENSITY

Structure

3.1 INTRODUCTION

It is the actual volume occupied by the particles of food material. It is of the importance in the packaging, handling and other operations.

Objective

After studying this experiment, you should be able to:

- determine the true density of the food material.

3.2 EXPERIMENT

3.2.1 Principle

The material is filled in a container having a liquid already filled in it of known volume. The volume displaced by the sample particles is the true volume and ratio with its weight will give true density. It should be in kg per cubic meter.

3.2.2 Requirements (Equipment/Machinery/Instrument and Chemicals/ Material)

- Measuring cylinder (250 ml capacity)
- Analytical balance (Least count 0.001 g)
- Toluene

3.2.3 Procedure

- Accurately weigh a finely ground 100 g sample (W1).
- Now fill a 250 ml capacity measuring cylinder with toluene up to the 100 ml mark.
- Transfer the weighed sample into the liquid.
- Determine the change in volume (V1).
- Repeat above steps with two more lots of the same sample.

3.2.4 Observations

Parameters	Sample number		
	1	2	3
Weight of sample (W1), g			
Weight in the volume (V2), ml			

3.2.5 Results

Calculate true density using the formula given below. Take the average of three values and report the results in kg/m^3.

$$\text{True Density} = \frac{W1}{V1} \times 1000$$

3.3 PRECAUTIONS

- Filling of the cylinder up to 100 ml mark should be accurate.

EXPERIMENT 4 MEASUREMENT OF FAT/ OIL

Structure

4.1 INTRODUCTION

Fat or oil present in any food is the source of energy. The oils and fats are insoluble in water and soluble in some organic solvents. It may be present in the food material itself as in oilseeds or it may come during processing. Determination of fat / oil content is essential to know the calorific value of food.

Objective

After studying this experiment, you should be able to:

- determine the fat content of foods.

4.2 EXPERIMENT

4.2.1 Principle

Fats and oils are soluble in organic solvents like hexane, Isopropanol etc. but other constituents are not. Hence, the fat present in the food sample is dissolved into the solvent and afterwards solvent is removed by evaporation distillation (Boiling point of solvent is much less than that of oils/fat).

4.2.2 Requirements (Equipment/Machinery/Instrument and Chemicals/ Material)

- Soxhlet apparatus
- Extraction filter paper thimble
- Analytical balance (Least count 0.001 g)
- Sample grinder
- Organic solvent (Hexane, Isopropanol or diethyl ether), acetone

4.2.3 Procedure

- Thoroughly wash the boiling flasks and rinse with commercial grade acetone to remove any residual oil/fat.
- Dry the flasks by placing in hot air oven for 3-4 hours

- Weigh the flasks and label them.
- Weigh the extraction filter paper thimbles (in duplicate) and label them.
- Transfer 2-5 g samples in pre-weighed thimbles and determine their accurate weight.
- Plugged these thimbles with non-adsorbent cotton and place them straight in the soxhlet extraction tube.
- Fill the extraction tubes with solvent sufficient enough so that the siphon system starts working.
- Now fix the Soxhlet assembly properly and switch on the heaters.
- As soon as the initiation of boiling is indicated start the water connected to condensers and allow the extraction for 8 hours.
- After 8 hours switch off the heaters and allow cooling.
- The solvent is evaporated using vacuum oven at 50^{o}C or a water bath and then flasks with oil are weighed.

4.2.4 Observations

Parameters	Sample number		
	1	**2**	**3**
Weight of empty flask (w1)			
Weight of empty thimble (w2)			
Weight of thimble + sample (w3)			
Weight of flask + oil (w4)			

Fat / oil content is calculated by using the following formula.

$$\%\mathrm{Fat/oil\,(w.b.)} = \frac{(w4 - w1)}{(w3 - w2)} \times 100$$

4.2.5 Results

Calculate oil/fat content using above formula. Take the average of three values and report the results as percentage.

4.3 PRECAUTIONS

- The water supply should not stop during the experiment. If so, the heaters should be put off.

- Take care that solvent should not come in contact with any heated surface as it is highly inflammable.

EXPERIMENT 5 CRUDE PROTEIN (TOTAL PROTEIN)

Structure

5.1 INTRODUCTION

Proteins are fundamental food components, both functionally and nutritionally. Dietary protein is supplied from plant and animal sources. Proteins are needed to build and repair body tissue and for the metabolic functions of our bodies. The crude protein is determined by estimating total nitrogen in any food material.

Objective

After studying this experiment, you should be able to:

- determine the total protein content of foods.

5.2 EXPERIMENT

5.2.1 Principle

Total nitrogen in all the samples is determined by the Kjeldahl method. It is a three step experiment as given below;

1. **Digestion:** It results in complete hydrolysis of the sample converting all protein and other nitrogenous compounds into ammonia.

2. **Distillation:** Distillation of the digested sample is the process during which the ammonia is released which is trapped in boric acid solution to yield ammonium borate.

3. **Titration:** The solution containing ammonium borate is titrated against 0.1 or 0.01 N HCI.

The protein content is estimated by multiplying % Nitrogen by a '**Protein factor'** as given below. In case factor is not known, 6.25 is commonly used.

Protein/product type	Protein factor
Egg	6.25
Milk	6.38
Meat	6.25
Rice	5.95
Barley	5.83
Wheat (whole)	5.83
Wheat (flour)	5.70
Maize	6.25

5.2.2 Requirements (Equipment/Machinery/Instrument and Chemicals/ Material)

- Conc. sulphuric acid
- Catalyst powder: Contains Cupric sulphate (penta-hydrate) and potassium sulphate (1:5 w/w).
- Sodium hydroxide solution (50%)
- Boric acid – indicator solution.

  Solution A: It is prepared by dissolving 40g boric acid in 1.95 litres hot distilled water.

  Solution B: It is prepared by dissolving 0.01 of bromo cresol green in 10ml of 95% ethyl alcohol.

  Solution C: It is prepared by dissolving 0.05 g methyl red in 50 ml of 95% ethyl alcohol.

  Finally solutions B and C are mixed and 50ml of this solution is made up to 2 litres with boric acid solution.

- Digestion assembly including Kjeldahl flasks / tubes.
- Distillation assembly
- Burette, pipette, conical flasks etc.

5.2.3 Procedure

1. Digestion of sample

- Accurately weigh 50 to 100mg sample (in duplicate) and transfer into two different Kjeldahl digestion tubes and label them.

- Add 4 ml conc. sulphuric acid and 100mg of catalyst powder to each digestion tube.

- Place the tubes on a heater to allow digestion at slow heat (100^{o}C) for 30 min. and gradually increase the temperature to 200^{o}C in about 1hour and finally to 420^{o}C until the colour of the content changes from dark brown to bluish green.

- The digested samples are then removed from heater and allowed to cool.

2. Distillation of sample

- Thoroughly clean the distillation unit and allow preheating.
- Now add 10 to 15 ml distilled water to each Kjeldahl tube/ flask.
- Close the stopcock and fill the reservoir with water to 2/3 its volume.
- Now transfer the diluted digested sample into the sample funnel and open the stopcock to allow the sample to drop into the mixing chamber.
- Rinse the Kjeldahl tubes with 10-15ml of distilled water and add the wash water to mixing chamber.
- Close the stopcock of the sample addition funnel and add sodium hydroxide (50%) solution to the sample funnel.
- Place the receiver conical flask containing 10 ml of boric acid with indicator with the outlet tube properly submerged into the solution.
- Now allow the sodium hydroxide solution to drop slowly into the mixing chamber by gently opening the valve of the sample addition funnel. Add 15-20ml of distilled water to the sample addition funnel and allow it to drop into the mixing funnel. Now close the sample addition funnel leaving some residual water in the funnel to work as water seal.
- Start heating of the content of the mixing chamber and continue for 20-30min, or until the colour of the indicator solution is changed from bluish purple to bluish green. Collected 15-20 ml of distillate.
- Finally slow down the heating intensity and gently remove the receiver flask while rinsing the outlet tube.

3. Titration

- Now titrate the distillate against 0.01 N HCl till the bluish green colour changes to pink.
- Run a blank preparation which has been identically prepared except that it does not contain the sample.

5.2.4 Observations

Parameters			
Sample titration value, ml			
Blank titration value, ml			

% Nitrogen is calculated as follows:

$$\%\text{Nitrogen} = \frac{(\text{Sample titre} - \text{Blank titre}) \times \text{N} \times 14 \times 100}{\text{mg of sample}}$$

N = Normality of HCl

% Crude protein = %Nitrogen × Protein factor.

5.2.5 Results

Calculate crude protein using above formula. Take the average of three values and report the crude protein content in percent.

5.3 PRECAUTIONS

- The digestion should be done in a closed cabinet so as to avoid inhalation of the fumes.

- During distillation, the outlet tube must be submerged into boric acid.

EXPERIMENT 7 FREE FATTY ACIDS (FFA)

Structure

7.1 INTRODUCTION

A small quantity of free fatty acids (FFA) is usually present in oil / fat along with the triglycerides. The content of FFA is known as acid number / acid value. It increases during storage of oil / fat as such or on oil/fat rich foods. Oil used for food purposes should have FFA level less than 1.5% as its keeping quality relies upon the FFA content.

Objective

After studying this experiment, you should be able to:

- determine the free fatty acid content of oil.

7.2 EXPERIMENT

7.2.1 Principle

The content of FFA in an oil is estimated by titrating it against KOH in the presence of phenolphthalein indicator. The acid number is defined as the amount (in mg) of KOH required neutralizing the free fatty acids in 1g of oil sample.

7.2.2 Requirements (Equipment/Machinery/Instrument and Chemicals/ Material)

- Solvent (Mix 100ml of 95% aqueous ethyl alcohol with 100ml of diethyl ether. Neutralize the solvent with 0.1N using phenolphthalein indicator).

- Potassium hydroxide, 0.1N

- Indicator dye (Dissolve 500mg phenolphthalein in 50ml 95% ethyl alcohol)

- Water bath

- Analytical balance

7.2.3 Procedure

- Transfer 10g accurately weighed sample of oil into 250ml Erlenmeyer flask and add 50 ml of neutralized solvent. Add a few drops of phenolphthalein indicator.
- Keep in water bath at 50°C for 15min with continuous agitation.
- When the content is properly mixed titrate the content against 0.1 KOH until the appearing pink colour persists for 15 sec.

7.2.4 Observations

Parameters	**Sample number**		
	1	**2**	**3**
Titre value, ml			

7.2.5 Results

Calculate FFA content in terms of acid value using the formula given below. Take the average of three values and report the results.

$$\text{Acid value} = \frac{\text{Titre value} \times \text{Normality} \times 56.1 \text{ of KOH}}{\text{Weight of the sample (g)}}$$

7.3 PRECAUTIONS

- Continuous agitation is required while titrating.