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

Block 2 Characteristics of Edible Agricultural Products

Block 3 Nutrition

Block 4 Quality Aspects

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.