
UNIT 9 ELEMENTS OF FOOD SCIENCE

Structure

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9.0 OBJECTIVES

After reading this unit, you should be able to:

- understand definition of food, its constituents, properties and their significance.
- know about quality attributes of food like flavour, odour, colour etc.
- learn regarding aroma of food and its importance
- know about safety aspects of food – like toxicity, hazards and food adulterants.
- understand importance of food biotechnology and its applications alongwith functions of food additives.
- know factors responsible for spoilage of food and its effects.
- learn regarding recent trends in food processing and preservation alongwith products and preservation.

9.1 INTRODUCTION

Food has been a basic part of existence of all living organisms. It is not only intimately woven into the physical, economical, psychological and social life but also part of social, community, national and religious life of human being. It is also be used as an expression of love, friendship and social acceptance. Virtually all foods are derived from living source such as plants and animals, thus it consists of “edible bio-chemicals.”

Because food is primary need for human being so, scientific study of food is essential endeavor and adventurous for mankind. Food Science can be defined as a application of basic sciences and engineering to study the fundamental physical,

chemical, biological, biochemical and behavioral science to nature of food, principles of food processing and marketing of food.

9.2 DEFINITION OF FOOD

Food may be defined as material, usually of plant or animal origin, that contains or consists of essential body nutrients, such as carbohydrates, fats, proteins, vitamins, or minerals, and is ingested and assimilated by an organism to produce energy, stimulate a growth, and maintain life.

Western food law defines four categories of object as food:

- Any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans whether of nutritional value or not;
- Water and other drinks;
- Chewing gum;
- Articles and substances used as an ingredient or component in the preparation of food.

9.3 CONSTITUENTS OF FOOD, PROPERTIES AND THEIR SIGNIFICANCE

All plants and animals need food to survive. However, the term food is very general. We need molecules that serve as a source of energy, which serve as components for cells and tissues, and that serve as energy reservoirs. There are three main group of constituents and their derivatives in food namely carbohydrates, fats, and proteins. In addition to these there are inorganic, organic and minerals component present in comparatively small proportion that includes vitamins, enzymes, emulsifiers, acids, oxidants, anti oxidants, pigments and flavours. All of these molecules are classified as nutrients. There is also the ever present and very important constituent, water. These components are arranged in different foods to give the food their structure, texture, flavour, colour, and nutritive value. In this section we will study molecules that give us energy (carbohydrates), those which are cell components and building blocks (proteins), those which serve as energy reservoirs (lipids), and the 'helper' molecules (vitamins and minerals).

Water :- Water is considered a nutrient because it is essential to life, as we know it. Under certain conditions, a person may survive without food for about 5 weeks but cannot survive without water for more than a few days. Living things are mostly water. It is part of our cells and our blood and it helps to control waste and body temperature. Water is needed at molecular level, cellular level and at the metabolic and functional level. It is major solvent for organic and inorganic chemicals involved in biochemical reaction, which is essential for life. Water is principal medium for transporting nutrients in body and also control and maintain normal body temperature.

Carbohydrates :- Energy producing food substances made up of carbon, hydrogen and oxygen that make up about half of our food intake. Carbohydrates are organic compounds having basic structure $C_x(H_2O)_y$. Carbohydrates can be found in many forms. Plants are the main source for carbohydrates and provide the major part of the energy in our diets and assist in the utilization of fats. Carbohydrates consist of starch, sugars and some related substances such as sugar

alcohols (e.g; sorbitol) and organic acids (e.g; citric acid). Carbohydrates are mainly found in cereal foods, fruits and vegetables. They may be in simple (sugars) or complex (starches and fiber) form. The most important types of carbohydrates in food are sugars, dextrin's, starch, cellulose, hemi-cellulose, pectin's, gums and lignin. Simple sugars are most easily digested, followed by starch, hemi cellulose, lignin, and then cellulose.

Carbohydrates play a major role in food. It is stored as energy reserves as a starch in plants and as glycogen in case of animals. Carbohydrates may also act as primarily supporting structure in plant kingdom as a cellulose and function as essential component of vitamins. Glucose in the blood is a ready source of energy for animals. Carbohydrates consumed by body in form of food help the body to use fat efficiently by supplying organic acids formed as an intermediate in the oxidation of carbohydrates. This organic acid is required for the complete oxidation of fat to CO_2 and water. Carbohydrates also exert a protein-sparing effect.

Some carbohydrates such as glucose, fructose, maltose, sucrose and lactose are readily soluble in water to form syrup and act as sweeteners in food. They supply energy and also prevent a growth of microorganism in higher concentration. Some of them combine with protein to give dark colour and also give body and mouth feel to solutions in food.

Starches are of plant origin and quite important in foods. They are not sweet and not soluble in cold water but form paste and gel in hot water. Starches work as reserve energy sources in plants and supply energy in nutrition. They not only have effect on texture of a food but also use as food ingredient in a special type of food to get desired viscosity at minimum heating.

Cellulose and Hemi cellulose are abundant in plant kingdom, which act as a supporting structure in plant tissue. They are insoluble in cold and warm water and are digested by man so does not yield energy. They are important in food because they hold together in bundles forming fiber and act as a dietary fiber.

Pectin form gels when mixed with sugar and acid, commonly used in gem and jelly manufacturing. Pectin's and gums are added to food as a thickener and stabilizer agent. They also control viscosity in fruits and vegetables pulp like tomato paste and stabilize fine particles in juices

Lipids :- Lipid is an essential nutrient that provides concentrated energy, contributes to the palatability of food, acts as a carrier of fat-soluble vitamins, and supplies essential fatty acids. Lipids are the second energy compounds next to carbohydrates. Lipids can be found in both solid and liquid forms. Those lipids that are liquid at body temperature are commonly referred to as oils, while those that are solid at body temperature are referred to as fats. Lipids contain more hydrogen and oxygen, respectively, than carbohydrates of the same size. This means that lipids contain more energy than carbohydrates, approximately 2.5 times as much. Lipids are not providing a structural strength to plant and animals tissues. All lipids are made from chains of fatty acids. These chains contain carbon atoms linked to each other, with hydrogen atoms attached to the open slots of the carbon atoms. Each fatty acid has a carboxyl end, which has a carbon atom attached to the previous carbon, a hydroxyl (OH) group, and double bonded to and oxygen atom. The opposite end of the chain has a carbon atom attached to the previous carbon atom, and also attached to three hydrogen atoms. This is called a methyl group

All lipids are classified as either saturated or unsaturated. Saturated fatty acids have no double bonds between the carbon atoms. This means that all carbon atoms in the chain, except the two terminal carbon atoms, are attached to two carbon atoms and two hydrogen atoms, all by single bonds. Thus, if the chain contains as many hydrogen atoms as it can hold, it is saturated. Unsaturated fatty acids have carbons, except the two terminal carbon atoms, that can be double bonded to the previous or next carbon atom in the chain. Thus, the chain does not have as many hydrogen atoms as it could hold and is considered unsaturated.

Lipids can also be classified into three different groups: simple, compound, and derived.

Simple lipids can be classified as either true fats or waxes. True fats contain fatty acids, which are attached to a molecule of glycerol. Waxes contain fatty acids attached to an alcohol molecule via an ester-type bond.

Compound lipids are those molecules that have other groups besides the fatty acids and glycerol or alcohol. These extra groups are attached via an ester bond. Groups can include nitrogen, carbohydrates, to form glycolipids, phosphoric acid, to form phospholipids, and proteins, to form lipoproteins.

Lipid molecules that are made from either simple or compound lipids by the process of hydrolysis are called derived lipids. Cholesterol is an example of a derived lipid. Lipids also supply a polyunsaturated fatty acids, one of which Linoleic acid is called essential fatty acids because animals cannot synthesize it adequately. In human infants absence of linoleic acid interferes with normal growth rates and results in skin disorder. Linoleic and other unsaturated fatty acid when present in higher high proportion of dietary fats can lower cholesterol levels under certain dietary condition. Lipids also physically insulate the body from rapid changes in temperature and help cushion organs from sudden injury.

Amino Acids :- Amino acids are nitrogen-containing compounds that are the building blocks of proteins. Amino acids are primarily composed of carbon, oxygen, hydrogen, and nitrogen process of making an antibody against a foreign antigen. There are 22 different amino acids in living things from which every protein in the body is made up of. Proteins are composed of different combinations of amino acids assembled in chain-like molecules. Amino acids are classified as essential amino acids and non essential amino acid. An essential amino acid is an amino acid that cannot be synthesized by the organism because humans do not have all the enzymes required for the biosynthesis of all of the amino acids. and therefore must be supplied as part of its diet and non essential amino acid is an amino acid that can be synthesized by the organism. There are ten essential amino acids that are not manufactured by the body and must come from the diet, out of which eight amino acid are generally regarded as essential for humans: tryptophan, lysine, methionine, phenylalanine, threonine, valine, leucine, isoleucine. Two others, histidine and arginine are essential only in children. An non essential amino acid are for an organism and can be synthesized by the organism in a body in sufficient quantity.

In chemistry, an amino acid is any molecule that contains both amino and carboxylic acid functional groups. In biochemistry, this shorter and more general term is frequently used to refer to alpha amino acids: those amino acids in which the amino and carboxylate functionalities are attached to the same carbon consisting of a carboxyl group (COOH), an amino group (NH₂) and a side chain.

All the tissues of hair, skin, nails and organs are made up of proteins and therefore will be influenced by the amino acids. In addition to the tissues digestive and regulatory enzymes, hormones, blood sugar, blood proteins and brain chemicals are also composed of amino acids. So amino acids are to support muscle growth, fat regulation, brain stimulation, or dietary fortification in animals. Unlike fat and starch, the human body does not store excess amino acids for later use. So, the amino acids must be in the food every day.

Proteins :- Proteins are highly complex nitrogenous compounds found in all animal and vegetable tissues and is one of the basic components of food and makes all life possible and are large compounds that are formed by linking amino acids together in long chains. They contain carbon, hydrogen, and oxygen like carbohydrates and lipids, but they also contain nitrogen. Some proteins may also contain sulfur, phosphorus and iron. Proteins are the building blocks of cells, tissues, and organs. Proteins are fundamental components of all living cells and include many substances, such as enzymes, hormones, and antibodies, which are necessary for the proper functioning of an organism. They are essential in the diet of animals for the growth and repair of tissue. Proteins are used for specific vital process such as growth, replacement of metabolic losses and damaged tissue, reproduction, lactation as well as being a component of all living cells. They provide for the transport of nutrients, oxygen and waste throughout the body. They provide the structure and contracting capability of muscles. Protein can also be used as an energy source only when carbohydrates and fats are not available. Proteins are essential for growth and repair. They also play a crucial role in virtually most of biological processes in the body. All enzymes are proteins and are vital for the body's metabolism. Muscle contraction, immune protection, and the transmission of nerve impulses are all dependent on proteins. Proteins in skin and bone provide structural support. Many hormones are proteins. Protein can also provide a source of energy. Generally the body uses carbohydrate and fat for energy but when there is excess dietary protein or inadequate dietary fat and carbohydrate, protein is used. Excess protein may also be converted to fat and stored.

In addition to their natural value, Proteins are selected for specific functional attributes including dispersibility, viscosity, cohesion, elasticity, emulsifying effect, formability, foam stability and fiber formation.

Vitamins :- Vitamins are needed by humans in very small amounts to maintain health. They are also organic compounds. Most vitamins act as cofactors in reactions that take place in the body. Many vitamins can be synthesized in the body, and therefore, do not need to be included in the diet. However, some vitamins cannot be synthesized by the body and must be supplied. Vitamins function in enzyme systems which facilitate the metabolism of proteins, carbohydrates and fats.

Vitamins are conventionally divided in two groups, fat soluble vitamins and water soluble vitamins. Fat soluble vitamins are A, D, E and K, while water soluble vitamins are C and several members of vitamin B complex.

Vitamins are required for essential metabolic activities and several functions as a part of enzymes. Vitamins increase absorption of calcium and phosphorus from intestinal tract, essential for blood clotting, necessary for the normal function of protein collagen and function in transmission of nerve impulse. Vitamins act as antioxidants, favour absorption of iron and play an important role in maintaining stability of biological membranes. Vitamins are also remedies for numerous diseases and as an agent to prolong youth and increase sexual potency.

Minerals :- Like vitamins, minerals are needed in only small amounts. However, minerals are not considered to be organic compounds. Minerals are actually elements. They can be classified according to their need into two groups: macro- and micro minerals. Minerals also act like vitamins in that they help to control many body processes.

Minerals are essential part of every living cell. Minerals are necessary for function of several enzymes system, control of fluid and maintain electric potential in cell and nerve membranes, helps in regulate and maintain osmotic pressure, pH equilibria, body fluid volume in body. Some minerals are essential constituent of enzyme involved in carbohydrates, protein metabolism and nucleic-acid synthesis.

9.4 QUALITY ATTRIBUTES OF FOOD

Sensory Analysis :- Sensory science is a fast developing branch of food science and technology and is getting the attention of an Indian Food Industry. Sensory analysis is defined as “ a scientific discipline used to evoke, measure, analyze and interpret the reaction to those characteristics of food/beverage as they are perceived by the senses of sight, taste, touch and hearing”. Sensory quality of food products is described in terms of colour and appearance, odour, texture, mouth feel, aroma, taste and after taste.

Sensory evaluation of quality by a panel of judges is essential in most food experiments. Sensory perception of Food Quality is flavour, odour, mouth feel, colour etc.

1) Elements of flavour

A. Taste-

1. Sweet substances/ mostly nonionic/ tip of tongue.
2. Bitter substances- back of tongue.
3. Saltiness- tip of tongue.
4. Sourness- sides of tongue.

B. Odor- Pleasant sensations in eating come more from odor than taste-four fundamental Odor Sensations are

- a) Fragrant of sweet (flowery)
- b) Acid or sour
- b) Burnt or scorched
- c) Caprylic or goat-like

C. Mouth-feel

1. Sense of touch
 - a. Temperature
 - b. Tactile sensations- characteristics of food which influence tactile aspect of mouth-feel:
 - c. Consistency- important in fudge, ice cream, etc (smooth)

2) Pain Sense

- a) Pungency: onions, garlic, horseradish, vinegar, allspice, cloves, sage, mints, mustard, cabbage, turnips
- b) Bite-ginger, red, white, black pepper

D. Other aspects of sensation known as “flavour”

1. Alkaline taste
2. Unclassified - mono sodium glutamate
3. Psychological factors with reference to flavour unpleasant associations rejected

Physical Methods of Food Evaluation

- 1) Volume
- 2) Texture
- 3) Rheology- flow of matter (viscosity)
- 4) Appearance :- Colour

Chemical Analysis :- A chemical analysis is being done to correlate the results of sensory analysis with analytical data. It also helps to find out the significance of both analysis. Analytical data not only reflects on quality of food but also helps to improve quality of food. These results help in improving keeping quality and storage of food.

It is observed that both sensory and chemical analysis when consider together give true picture of product quality. In chemical analysis different properties or attributes of food are found out with help of different chemical methods and instruments. Examples are pH, moisture, fat, protein, carbohydrates, colour, texture, etc.

- 1) pH- acidity and alkalinity
- 2) Sugar concentration- refractometer

9.5 AROMA OF FOOD

As commercial environment of food industry become more competitive, there is an increasing need for maintenance and improvement of food and drink quality. Flavour is generally accepted as a most important sensory characteristic associated with food. Flavour perception consists of two components Aroma and Taste. Out of which aroma plays a very important factor related to quality and analysis of food. There are hundreds of volatile compounds that define the nature of the food and product identity, as well as contribute to consumer preference between brands of product. These compounds are also responsible for occurrence of off flavour and taints, which arise due to chemical and biochemical changes, microbial action or contamination.

Aroma in food is perceived by nose and mouth. There are approx. 1000 odorant receptor genes in the genome, the combinatorial receptor coding system should permit recognition of vast number of diverse aromas. Even if each odorant were encoded by these receptor, the no. of odorants that could be discriminated would be nearly 1 billion. Aroma of a substance depends upon its volatility, which are constantly throwing off molecules which are possibly odorous. Aroma is perceived when odorous molecules mixed with air are inhaled. At the top and back of the nose there are is a o patch of few cm. of yellowish skin, which is the sensitive area of all olfaction. As a odorous air passes through sensitive area the odorant molecules are absorbed by it. Odorant molecules are in rapid state of motion travelling at room temperature at a speed approaching that of sound and are hitting olfactory sensitive surface.

It is yet unknown how signals generated from different receptors in nose and mouth are dealt with in a brain. It is known that signals from olfactory neurons in the nose are ultimately sent to different brain areas, in some of which the conscious perception of odors mediate emotional and physiological effect.

Check Your Progress 1

Note: a) Use the spaces given below for your answers.
b) Check your answers with those given at the end of the unit.

1. Define food and its constituents.

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2. What are basic properties of Protein and Carbohydrates?

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3. What are quality attributes of food. Discuss sensory evaluation food.

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9.6 FOOD SAFETY

The safety of food is of utmost significance and has gained a worldwide attention. The concern about safe food is definitely not new, but the food safety crisis still exists in several parts of world including India. The chemicals which are used in the growing or processing of food is alleged to cause adverse effect in human and mammals. Coffee is normally adulterated with charcoal, cocoa with sawdust, olive oil with coconut and butter with margarine. An understanding of food safety is improved by defining two other basic concepts Toxicity and Hazard.

Toxicity:- Toxicity is the capacity of a substance to produce harm and injury of any kind under any condition.

Hazard :- Hazard is the relative probability that harm or injury will result when the substance is used in a proposed manner and quantity. Raw food such as meat, fish, milk, fruits and vegetables are likely to be contaminated with harmful microorganism. Microorganisms are generally destroyed during cooking or processing of food. But some of the microorganism may survive due to inadequate heat processing. These pathogenic microorganisms are commonly found in contaminated food and are responsible for illness.

Food Adulteration :- Food adulteration is defined as the process by which the quality or nature of food product is adversely affected through the addition of foreign or an inferior substance and removal of vital element, such as fat from milk

and addition of water to it. Adulteration may be intentional or incidental. Intentional adulteration is caused by addition of foreign or an inferior substance in food like sand, chips, stone, mud, chalk powder, mineral oil, harmful colour etc. Incidental adulteration is caused by some toxic pesticide residue, by rodents and insects, tin from can, larvae in food, microorganism etc.

Food Industries, however, are most concerned about the microbiological safety of its products. Big food companies in many parts of the world adhere to a code of manufacturing practice known as “Good Manufacturing Practice” (GMP). This code helps to assure that products are manufactured in conditions of proper storage and sanitation. Hazard Analysis and Critical Control Points (HACCP) are followed to make sure that there is no chance of contamination or error during processing.

The safety of food has gained a worldwide attention due to scientific awareness. Safe food has replaced adequate food. People have right to expect the food they eat to be safe and suitable for consumption. Everyone including farmer and grower, manufacturer, processor, food handlers and consumer has a responsibility to assure that food is safe and suitable in consumption. We should practice clean habits in handling, cooking and storage of food to ensure the complete safety.

9.7 FOOD BIOTECHNOLOGY

The traditions of food and the modern knowledge of biology are blended effortlessly to provide tailored solutions to the food industry and develop cost effective, bio friendly technologies pursuing health and nutrition to all sections of the society. It has been observed that there is no food technology without biotechnology. Biotechnology is not a single area but a multiplication of many areas into one. Whenever something is produced from a living process—living plants, animals, bacteria, fungi etc., biotechnology is the intentional addition of a step somewhere in the value addition chain to make the product better. In the 1990's the impact of molecular biology was felt. This impact took us into enzyme engineering, protein engineering, relooking at nucleic acids and even looking at nutrition from the metabolic point of view. Then from the late nineties the entire perspective has shifted to the level of molecular mechanisms, with the knowledge gained through biotechnology. Like in plant biotechnology, it is the specialized areas of algal biotechnology and tissue/cell culture of plants as also molecular biology and genetic engineering. It has pioneered the development of technology for cultivation of international-quality Spirulina, and its utilization in food, feed and pharmaceutical sectors. It includes processes of extraction of natural colors (a rare natural blue pigment phycocyanin from cyanobacterial biomass) and food flavourants by bio transformation of algal cells (Vanilla flavor compound). We do not understand the biotechnology involved because we take it for granted. Now the question is are we optimizing these processes? How do we make them better? All this knowledge has to be formalized, made reproducible and hygienic. Tomorrow food technology in the world is related to biotechnology on the health basis. We should focus on this as we have the required expertise, the database, the tradition and the biodiversity. There exists a large opportunity not only from the business point of view but also from the point of usefulness to the end consumer.

9.8 FOOD ADDITIVES

Food Additives are certain compounds that are non nutritive substance added

to food generally in small quantity to enhance taste, provide colour, or protect against the growth of microorganisms. It is any substance or mixture of substances other than the basic foodstuff, which is present in food as a result of any phase of production, processing, packaging, or storage.

Food additives serve five main functions:

1. Food additives maintain product consistency provide a consistent texture and prevent products from separating. It provides thickness, uniform texture as well as anti caking agents properties to free flow of food.
2. Food additives improve or preserve the nutrient value fortification and enrichment of foods and make it possible to improve the nutritional status. For example, vitamins and minerals are added to many foods including flour, cereals, margarine, and milk. All products that contain added nutrients must be labeled.
3. Food additives maintain the wholesomeness and the palatability of foods. It reduces the spoilage in food through air, fungi, bacteria, or yeast and also help baked goods preserve their flavour by preventing the fats and oils from becoming rancid. They also keep fresh fruits from turning brown when exposed to the air, which allow food-borne illnesses to occur.
4. Food additives control the acidity and alkalinity in food to provide leavening, specific additives assist in modification of the acidity or alkalinity of foods to obtain a desired taste, colour, or flavour.
5. Food additives provide colour and enhance a flavour in food. Certain colours improve the appearance of foods. There are many spices and natural and synthetic flavours that bring out the best in the flavour of food.

The food additives are mainly classified under 11 broad groups

1. **Preservatives :-** These are a chemicals that preserve food from bacteria, yeasts and moulds. Most common are sodium benzoate, sodium and calcium propionate, sorbic acid, benzoic acid etc.
2. **Antioxidants :-** These are a compounds which are used to prevent oxidation of fats in many food. It also helps to protect food from developing rancidity due to length of time during storage. The important antioxidants are butylated hydroxy anisole, butylated hydroxy toluene, propyl gallate, ascorbic acid etc.
3. **Sequestrates :-** These are chelating agents and sequestering compounds which react with trace elements presents in food and remove it from solution because trace elements are active catalysts of oxidation and discoloration in food products. Sequestrates such as ethylene diamine tetra acetic acid, poly phosphates and citric acid react with trace elements and inactivate them.
4. **Surface active agents :-** Mainly these are emulsifiers normally use to stabilize oil in water and water in oil mixtures, gas in liquid and gas in solid mixture. Most common synthetically prepared emulsifiers are mono and diglycerides and their derivatives.
5. **Stabilizers and thickeners :-** Stabilizers and thickeners are additives which stabilize and thicken foods by combining with water to form gels. These includes gum arabic, carboxyl methyl cellulose, pectin, amylase, gelatin and others.
6. **Bleaching and maturing agents :-** These are oxidizing agents used in food to improve its colour, baking and solubility properties. Benzyl peroxide is used as an oxidizing agent which bleach yellow colour, hydrogen peroxide is used to whiten the colour of milk for certain kind of cheese.

7. **Food colour:-** Food colour are added to many food items, to improve desire appearance, to give public appetizing and attractive qualities in food. Colours from natural materials such as annatto, caramel, carotene, and saffron are most preferred in food.
8. **Non-nutritive and special dietary sweeteners :-** These are normally used as non-nutritive sweeteners used in manufactured food and soft drinks to maintain low calories mainly for diabetic and calories conscious people. The well known substance are saccharin, aspartame etc.
9. **Nutrient supplements :-** Basically these are vitamins and minerals added as supplements and enrichment mixtures to a number of products like vitamin D added to Milk, vitamin A added to margarine.
10. **Flavouring agents :-** These are a chemicals used in natural and synthetic form act as a flavouring agents in a food. Some well known natural flavouring agents are spices, herbs, essential oils, plant extracts etc., Well known synthetic flavouring agents are benzaldehyde, ethyl butyrate, methyl anthanilate etc.
11. **Miscellaneous :-** A various types of solvents are used in manufactured food and soft drinks like dichloromethane and trichloroethylene are used for decaffeinating of coffee and tea.

9.9 FOOD SPOILAGE AND ITS EFFECTS

Food is very sensitive commodity and it directly affects human health. All foods deteriorate, some more rapidly than others. So, it is very essential to handle it properly right from raw material through processing, packing, storage and transport to the consumers. Spoilage in food is directly related to poor sanitation practices and improper food handling. When food spoilage starts, it undergoes various physical and chemical changes that lead food to inedible and hazardous. The major type of food spoilage is microbiological, biochemical, physical/mechanical and chemical.

Microbiological Spoilage :- Micro-organisms activity are considered to be a primary cause of food spoilage. Micro-organisms are found everywhere, they are present in soil, water, air, and on fruits and vegetables. The factors responsible for growth of micro-organisms are suitable temperature, humidity and substrate to live on such as food and beverage. The most common form of micro-organisms are moulds, yeast, bacteria and virus. All micro-organisms need a food, a favourable temperature, a favourable moisture to grow. So, in food preservation it is impossible to eliminate food as a factor in microbial growth, attention must be given to control of other conditions that aid growth.

Biochemical Spoilage :- Biochemical spoilage is mainly cause by natural food enzyme present in food. Enzymes are organic catalysts produced by living cells. These are compact catalysts that initiate many complicated chemical reactions in plants and animals tissues like ripening of fruits and maturing of vegetables, natural tendering and ageing of meat etc. Enzymes are proteins and it also be responsible for development of off-odours, off-colour, off taste in food, if enzymatic reactions are un controlled. Normally enzymes are activate between 0 °C to 60 °C and optimum temperature of its action is 37 °C but all enzymes are inactivate at 80 °C.

Physical/ Mechanical Spoilage :- Physical/mechanical spoilage can be brought out by temperature changes, moisture and dryness, cut injury, compact injury, vibration injury, impact injury. Excessive heat destroy emulsion, dehydrate food

and destroy vitamins. Freezing also cause deterioration like freezing of milk break emulsion, cause fat to separate. Excess amount of moisture cause caking, lumping, stickiness etc. in powder and also support growth of micro-organism.

Chemical Spoilage :- Such type of spoilage caused by interaction of certain ingredients contained in food with air, light, time, temperature etc. It causes undesirable change in food such as destruction of food colour, flavour, vitamins.

Check Your Progress 2

Note: a) Use the spaces given below for your answers.
b) Check your answers with those given at the end of the unit.

1. What do you understand by Food adulteration?

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2. What are basic function of Food additives?

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3. Define different Food spoilage.

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9.10 RECENT TRENDS IN FOOD PROCESSING AND PRESERVATION

Preservation by Irradiation :- Irradiation heating employ radiant energies which affect foods when their energy is absorbed. Food irradiation is used primarily as a preservation method through gamma rays, but it also has potential as a more general unit operation to produce specific change in food material. This radiation will kill or harm the microorganisms that are on the food. The radiation passes through the food and is not stored in it. Gamma rays have the most potential for use in foods. Cobalt-60, a radioactive isotope of cobalt, is commonly used as the source for the gamma rays. These gamma rays work by stripping electrons from atoms in the microbe. Commonly, these electrons are stripped from atoms that help to make up the DNA of the microbe. The microbe is then irreversibly damaged because this DNA is the blueprint for the life functions of the microbe, such as reproduction as protein formation. The potential uses of irradiation heating in food industry are extension of storage life by inhibiting of sprouting, delay in maturation, sterilization of food, elimination of specific pathogen, increasing digestibility, insect disinfestations etc.

Microwave Heating :- Microwave heating is form of radiant energy fall between radio waves and infrared radiation with wave-lengths is equivalent between 0.025-

0.75 m. For food application the approved and most commonly used microwave frequencies are 2450 MHz and 915 MHz. Microwaves travel in straight line, reflected by metals, pass through air and absorbed by several food constituents including water. When they passing through a material to the extent that are absorbed, they heat the absorbing material and lose its electromagnetic energy. The current and potential uses of microwave heating in food industry are many and of growing importance in baking, concentrating, cooking, curing, drying, pasteurizing, sterilizing, thawing etc.

Fermentation :- It may define as oxidation of complex organic compound mainly carbohydrates with help of enzyme producing micro-organism. It plays important role in preservation of food from earlier times like production of cheese, curd, butter from milk, production of alcoholic beverages, pickle, sausages, vinegar, bread, biscuits etc. In fermentation a waste material or inexpensive raw material converted in to valuable material through micro-organism. In this process a selected micro-organism cause oxidation at control environmental condition to grow and covert a organic compound in to valuable products. A most common enzymes normally used in a food industry are amylase, pectinase, protease, invertase etc.

Modified Atmospheres :- Modifying the atmosphere in which a food is packaged can have a effect on the shelf-life of the food. It is because of this extension of shelf-life and other effects that many companies are now using modified atmospheres for their products. The process in which modified atmospheres work is the use of carbon dioxide (CO₂). There have been many studies on the effects of carbon dioxide to microorganisms. It affects the permeability of the membranes surrounding the cells. Carbon dioxide interferes with protein binding amino acids in the cell. And finally it has been suggested that the carbon dioxide interferes with enzymes and their activity. Even carbon dioxide under pressure has a greater anti microbial effect than carbon dioxide that is not under pressure.

Vacuum Packaging :- In vacuum packaging, the food product is first placed into a gas-impermeable bag. The air within the bag is then sucked out and the bag is sealed. This reduces the pressure inside of the bag. Microbes on the food product continue to respire, but there is now a finite amount of oxygen in the bag, and since the bag is impermeable to gases, the carbon dioxide that is given off cannot escape. This buildup of carbon dioxide and the decrease in available oxygen is principle behind vacuum packaging.

9.11 NEW PRODUCTS AND EQUIPMENTS

Medicinal Value Products :- It has been seen, that the use of medicinal plant is found in all the four Vedas namely Rigveda, Samveda, Yajurveda and Atharvaveda. Ayurveda is a text on the preventive and curative aspects of disease, is a part of Atharvaveda. In today's scenario, India is also emerging as one of the leading manufacture and exporter of raw herbs and their allied products in international market. According to latest reports, the use of herbs and their allied products like syrups, candies, powder etc. are increasing rapidly in most of developed as well as leading developing countries in a world. Latest research shows that herbs have a great potential to protect human civilization from non-chronic as well chronic diseases without affecting human metabolism and with out causing any side effects on human body. Even in most part of the world, large number of population is switching over to herbal products. Because even a single herb can protect the human body from different diseases and keeps it healthy and fit.

Low Calories Products :- Today, in the fast growing world, most of the people, mainly urban population of world are more conscious about their diet to stay healthy and fit. Therefore, people need such type of products which not only have low calories and low contents of sugar, fat and carbohydrates but also have a good nutritive and therapeutic values. Aspartame is use as a non-caloric sweetener in number of products. It was discovered in 1965 and entered the market in the 80's. A number of national and international organizations have assessed the safety of aspartame. Aspartame is "200 times sweeter" than ordinary sugar resulting in consumption of fewer calories. For a weight conscious society, low calories are always a source of attraction. Keeping in view the above, basic aim is to develop a quality product for diabetic and calories conscious people by keeping the basic properties of raw material intact i.e. low glycemic index. This will result in products with good preservative and herbal properties, sensory evaluation, mass acceptability, and easy consumption by diabetic population. The most common low calories products are fruit juices in form of ready to serve drinks squashes, cordials, syrups, dry powder, tablets etc.

Vacuum Puffing Dryer :- In this process, a puffing units consists essentially of a shallow receptacle with an air tight lid, connected through a quick opening valve to a vacuum reservoir maintained at 60-64 cm Hg vacuum. The lid of the receptacle can be closed and opened instantly by a pneumatic cylinder, which open by the suction from the reservoir. The entire operation of transferring trays to receptacle, closing a lid, applying and releasing the vacuum and open the lid, can be completed within 15 sec. The puffed porous piece be dried in a dryer at about 66°C with an air velocity of 300 m/min. A product consists of a excellent consumer acceptance.

Freeze Dryer :- In normal drying process a product loses its weight as well as its shape, which is not acceptable in certain cases from consumer point of view. But in this process product loses its weight but not shape and products remain firm after processing. In freeze drying, a material is placed in the lower chamber at very low temperature and frozen material is dried in upper chamber under very high vacuum. The material is directly dried by sublimation of ice without passing through intermediate liquid stage. Such type of products are highly hygroscopic, excellent quality of taste, flavour and easily reconstituted.

9.12 FOOD EVALUATION

Evaluation of food is an important part of developing new food products and analyzing its market potential. It has also effect on economical preparation and distribution of safe and nutritious food. Evaluation provides information pertinent to the quality of food products involving chemistry, physics, technology of food, degree of excellence, which encompasses taste, aroma, texture, appearance, nutritional content, as well as factor that determine the safety of food. Evaluation of food could be conducted by two ways.

1. Subjective evaluation
2. Objective evaluation

Subjective evaluation :- The evaluation of food is conducted by human sensory organs is called subjective evaluation. The important sensory organ by which man perceives his food is sight, smell, taste, touch and hearing. Most important sensory properties of food is flavour, taste and odour, temperature consist of hot and cold, appearance including colour, texture and mouth-feel. Food preparation on large

or small scale is a art of combination of these properties to please the eyes, nose and palate. So, sensory evaluation is a scientific discipline used to evoke, measure, analyse, and interpret reaction to these characteristics of food that are perceived by senses. There are two main group of methods of sensory evaluation (*a*) analytical method (different ranking and quality test) (*b*) subjective method (preference, consumer and market tests).

Objective evaluation :- The evaluation of food is conducted by use of instruments is called objective evaluation. Objective evaluation is conducted by instruments provided they give information that correlates well with sensory characteristics, because sensory evaluation is costly as well as time consuming. Objective measurement of food is preferable to subjective measurement only if the objective tests can provide a precise measure of sensory quality. Objective evaluation involving instruments may be categorized into two types (*a*) imitative measurement (*b*) non-imitative measurement. Imitative measurement is done by instruments that imitate the way in which human perceive the sensory property like a machine that duplicate the bite of human teeth. Non-imitative measurement includes any determination of chemical/ physical properties of food system that statistically correlates with sensory properties like taste intensity of particular solution may be predicted by determining the hydrogen ion concentration.

Check Your Progress 3

Note: a) Use the spaces given below for your answers.

b) Check your answers with those given at the end of the unit.

1. What do you mean by preservation of food by Irradiation?

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2. How Freeze Dryer works?

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3. How can you evaluate a Food?

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9.13 LET US SUM UP

Food Science consists of basic sciences and engineering to study the fundamental physical, chemical, biological, biochemical and behavioral science to nature of food, principles of food processing and marketing of food.

A basic aim of food science is to provide a food, which consists not only processing of food to maintain its nutritive value but also considers to increases shelf-life of a food. It also consists of different evaluation of food products to maintain a better

quality and reduce spoilage of food and its wastage. Even though a basic aim is also to develop new techniques of preservation and keeping quality of food and to develop new products having good nutritive value and quality with help of different branches of science and engineering.

9.14 KEY WORDS

Food Additives	: Food Additives are non nutritive substance added in to food in small quantity during processing to enhance its quality and shelf-life.
Fermentation	: Fermentation is a oxidative process to convert complex organic compound to a valuable product.
Preservatives	: Preservatives are a chemicals that preserve food from bacteria, yeasts and moulds.
Food Adulteration	: Food Adulteration is define as addition of foreign or inferior material and removal of vital elements from food.
Antioxidants	: Antioxidants are a compounds that are used to prevent oxidation of fats in food to protect a food from developing rancidity.
Toxicity	: Toxicity is the capacity of a substance to produce harm and injury of any kind under any condition.

9.15 SOME USEFUL REFERENCES

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9.16 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. Material, usually of plant or animal origin, that contains or consists of essential body nutrients, such as carbohydrates, fats, proteins, vitamins, or minerals, and is ingested and assimilated by an organism to produce energy, stimulate a growth, and maintain life. A basic food constituents are Water, Carbohydrates, Lipids, Amino acids, Proteins, Vitamins, Minerals.

2. Proteins are main components of all living cells, its include many substances, such as enzymes, hormones, and antibodies etc. which are necessary for the proper functioning of an organisms and are essential in the diet of animals for the growth and repair of tissue, growth, replacement of metabolic losses and damaged tissue, reproduction, lactation in living cells. Carbohydrates play a major role in food. Carbohydrates are organic compounds having basic structure $C_x(H_2O)_y$. Provide the major part of the energy in our diets, assists in the utilization of fats. Carbohydrates consist of starch, sugars and some related substances such as sugar alcohols and organic acids.
3. The quality attributes of food are

Sensory Analysis

Chemical Analysis

Sensory analysis may define as scientific discipline used to evoke, measure, analyze and interpret the reaction to those characteristic of food/beverage as they are perceived by the senses of sight, taste, touch and hearing. Sensory quality of food products is described in terms of colour and appearance, odour, texture, mouth feel, aroma, taste and after taste.

Check Your Progress 2

1. Food adulteration is defined as the process by which the quality or nature of food product is adversely affected through the addition of foreign or an inferior substance and removal of vital element, such as fat from milk and addition if water to it. Adulteration may be intentional or incidental Intentional adulteration caused by addition of foreign or an inferior substance in food like sand, chips, stone, mud, chalk powder, mineral oil, harmful colour etc. Incidental adulteration is caused by some toxic pesticide residue, by rodents and insects, tin from can, larvae in food, microorganism etc.
2. The basic function of Food additives are
 1. Food additives provide a consistent texture and prevent products from separation. It provides thickness, uniform texture as well as anti caking agents properties to free flow a food.
 2. Food additives improve or preserve the nutrient value fortification and enrichment of foods and make it possible to improve the nutritional status.
 3. Food additives maintain the wholesomeness and the palatability of foods and also keep fresh fruits from turning brown when exposed to the air, which allow food-borne illnesses to occur.
 4. Food additives control the acidity and alkalinity in food to provide leavening, specific additives assist in modification of the acidity or alkalinity of foods to obtain a desired taste, color, or flavor.
 5. Food additives provide color and enhance a flavour in food.
2. Spoilage in food is directly related to poor sanitation practices, faulty processing and improper food handling. When food spoilage starts, it undergoes various physical and chemical changes that leads a food to be inedible and hazardous. The major type of food spoilage is microbiological, biochemical, physical/mechanical and chemical.

Check Your Progress 3

1. Food irradiation is used primarily as a preservation method through gamma rays, but it also has potential as a more general unit operation to produce specific change in food material. This radiation will kill or harm the

microorganisms that are on the food. The radiation passes through the food and is not stored in it. These gamma rays work by stripping electrons from atoms in the microbe. Commonly, these electrons are stripped from atoms that help to make up the DNA of the microbe. The potential uses of irradiation heating in food industry are extension of storage life by inhibiting of sprouting, delay in maturation, sterilization of food, elimination of specific pathogen, increasing digestibility, insect disinfestations etc.

2. In freeze drying a material is placed in the lower chamber at very low temperature and frozen material is dried in upper chamber under very high vacuum. The material is directly dried by sublimation of ice without passing through intermediate liquid stage. Such products are highly hygroscopic, excellent quality of taste, flavour and easily reconstituted.
3. Evaluation of food is an important part of developing new food products, lower down cost of production and analyzing its market potential. Evaluation provides information pertinent to the quality of food products involving chemistry, physics, technology of food, degree of excellence, which encompasses taste, aroma, texture, appearance, nutritional content, as well as factor that determine the safety of food. Evaluation of food could be conducted by two ways.
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