PRINCIPLES OF FOOD SCIENCE AND NUTRITION

BSC (HONS.) AGRICULTURE

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By

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COURSE DETAILS

1. **Course No.** : FSN (Ag)-321
2. **Course title** : Principles of Food Science and Nutrition
3. **Credit hour** : 2(2+0)
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5. **Semester** : VIth semester
6. **General objectives** : To acquire a basic understanding of current trends in nutrition,functions, physico-chemical properties of foods, nutritional problems of thecommunity etc.

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1.	Introduction to food science	Basic terminologies, their definitions and relevance , PH of foods	1
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3	Colloidal chemistry as related to foods	Introduction, constituents of foods, stability of colloidal system	3
4	Water	Introduction, properties, types of water	4
		Water And Electrolyte Balance	5
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		Nutritional roles of carbohydrates, carbohydrate metabolism	7
6	Proteins	Introduction, classification, amino acids, properties of protein	8
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23	New trends in food science and nutrition	Functional foods, phytochemicals, health supplements, probiotics, sports nutrition	32

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LESSON-1
CONCEPT OF FOOD SCIENCE

Man's basic drive for food is to satisfy hunger. Food is built in to the physical, economic, psychological, intellectual and social life of man. It is a part of his culture.

When consumed, foods undergo digestive and other changes to supply the body it's requirements. After production and before consumption, foods are subjected to numerous physical, chemical, microbial or parasitic factors which may cause their spoilage or cause disease when consumed. To prevent this and to prepare food for immediate or future use, it requires processing, preservation and storage. Food for consumption should have proper appearance, colour, juiciness, texture, odour and taste.

Food is essential for growth, maintenance, repair and reproduction. It gives protection against various diseases.

Foods are composed of different kinds of nutrients .Six general kinds of nutrients found in foods are: Carbohydrates, proteins, fats, minerals, vitamins and water. In addition foods contain enzymes which function as catalysts in chemical reaction, coloring material and flavor compounds. The recommended dietary allowances (RDAs) are estimates of nutrients to be consumed daily to ensure the requirements of all individuals in a given population. The Indian Council ofMedical Research (ICMR) provides RDA for Indians.

1. **Agriculture**- is the art and science of cultivating the soil, growing crops and raising livestock. It focuses on production of foods.
2. **Food Engineering**(design food processing plants for proper processing of foods)
   Food engineering is a scientific, academic and professional field that interprets and applies principles of engineering to food manufacturing and operations, including the processing, production, handling, storage, conservation, control, packaging and distribution of food products.
3. **Food Microbiology**(microbial ecology related to food, food spoilage)
   The field of food microbiology is a very broad one, encompassing the study of microorganisms which have both beneficial and deleterious effects on the quality and safety of raw and processed foods. Some useful bacteria may be important because they change the functional properties of food stuffs resulting in new tastes, odors or textures. Microorganisms in food include bacteria, molds, yeasts, algae, viruses, parasitic worms and protozoa. These organisms differ in size and shape and in their biochemical and cultural characteristics.

4. **Food** is defined as anything solid or liquid which when swallowed, digested and assimilated, nourishes the body. Food is a mixture of many different chemical components.
5. **Food science:** The study of food science involves an understanding of the changes that occur in these components during food preparation whether natural or included by handling procedures. Many physical and chemical reactions occur during food preparation. These reactions may be result of the interaction between components, with the medium of cooking, study of food science also includes understanding the nutritive value of different foods and methods of preserving them during cooking. This information provides a foundation of theory and method on which to build the study of food preparation.
6. **Food additive:** is defined as non-nutritive substances added intentionally to food, generally in small quantities to improve its appearance, flavour, texture or storage properties.
7. **Food technology:** is the application of principles of food science and engineering to the processing and perspective large quantities of food.
8. **Food fortification:** is defined as the process whereby nutrients are added to foods in relatively small quantities to maintain or improve the quality of the diet of a group, a community or a population (WHO).
9. **Functional food:** provides health benefits beyond the nutrient contribution.
10. **Phytochemicals:** are non-nutrient compounds found in plant derived food that have biological activity in the body.
11. **Food safety and regulation:** is related to food sanitation in public health and rules and regulation governing it.
12. **Antioxidants:** include compounds that protect biological systems against the potentially harmful effects of processes or reaction that can cause excessive oxidations (USDA).
13. **Nutrition** is " the science of food, nutrients and other substances therein, their action, interaction and balance in relation to health and disease and the process by which the organism ingests, absorbs, transports, utilizes and excretes food substances".
14. Protein: Proteins are required for growth in children and maintenance of body weight in adults. Proteins also provide energy to a small extent. Proteins constitute about 20 percent of the body weight. Body proteins are derived from the dietary proteins. The body loses continuously someProteins quantity of proteinsand this loss has to be made up by dietary proteins. Proteins are made up of simpler chemical substances known as amino acids. The amino acid content of proteins has been found to differ from one protein to another. The nutritional value of a protein depends on its amino acid contents.
15. **Carbohydrates:** Carbohydrates are the main sources of energy for doing work. The carbohydrates commonly occurring in foods are starch, cane sugar(sucrose), glucose, fruit sugar (fructose) and milk sugar (lactose). About 50-70 percent of energy value (Calorie value) in the average diet is provided by carbohydrates. They are the cheapest source of energy. Hence, the diet should contain adequate amounts of carbohydrates to meet a greater part of the energy needs.
16. **Fats:** Oils and fats mainly serve as sources of energy. They contain some essential nutrients like essential fatty aids. Fats is essential for maintaining good health. Absence of fat leads to a deficiency disease affecting the skin known as phrynoderma.

17. **Minerals**: The body contains about 24 minerals all of which are derived from the diet. The important minerals are calcium, phosphrous, sodium, potassium ,chloride, magnesium, iron, copper, iodine, cobalt, fluorine and zinc. Minerals are essential for various body functions, Such as:
    a. Calcium and phosphrous for formation of bones and teeth.
    b. Sodium, Potassium and chloride for maintaining water balance in the body.
    c. Iron and copper for formation of hemoglobin,
    d. Iodine for the normal functioning of thyroid gland.
18. **Vitamins:** Foods contain certain essential chemical substances in very small amounts were called as vitamins. About 14 different vitamins discovered. All of them are essential for normal functioning of the human body. Inadequate intake of vitamins leads to the development of deficiency diseases. Vitamins have been grouped under two heads
    a. Fat soluble vitamins such as vitamins A, D,E, and K
    b. Water soluble vitamins, e.g. thiamine (vitamin B1), riboflavin (vitamin B2), niacin, pyridoxine (vitamin B6), vit-B12 pantothenic acid, folic acid, biotin, vit-C.
19. **Health** is defined by WHO as "A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity".
20. **Nutritional status** is "the condition of health of an individual as influenced by the utilization of nutrients".
21. **Malnutrition:**is "An impairment of health resulting from deficiency, excess or imbalance of nutrients".

22. **Nutrition survey** is "Ascertaining the nutritive quality of diets consumed and the nutritional status of the people in a given population ascertained by using various survey techniques".
23. **Food preservation:** Food preservation includes food processing practices which prevent the growth of microorganisms, such as yeasts, bacteria or fungi to the food and slow the oxidation of fats that cause rancidity.
24. **Food Spoilage:** Food spoilage may be defined as a process or change which renders a product undesirable or unacceptable for consumption.
25. **Sensory Properties of Food**

    Foods have several characteristics that require evaluation by sensory methods. The various food attributes that are judged on the sensory scale are flavour, texture, aroma and appearance. Sensory Properties of food:

    1. Appearance
    2. Flavor
    3. Taste/ Gustation
    4. Odor/aroma/fragrance
    5. Consistency and texture
    6. Chemical Factors
    7. Sound

26. Boiling Point

Boiling is the use of heat to change a substance from a liquid to a gas. Like the melting point, the boiling point of a pure substance is always constant. It changes if impurities or dissolved substances are present or by changes in atmospheric pressure. Pure water boil at 100 °C

Applications of Boiling Point

1. Boiling vegetables in salted water increases the boiling point above 100 °C.
2. In sugar cookery, the boiling points of sugar solutions is noted at various stages so that fondant, fudge, toffee, and caramel can be prepared.

27. Evaporation

Evaporation is a change of state from liquid to gas which takes place continuously from the surface of a liquid.

Volatile liquids vaporize easily, e.g., petrol and acetone.

Non-volatile liquids, such as oils, evaporate very gradually.

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Applications of Evaporation

1. Bread and cake if left uncovered, hardens and becomes stale because of loss of moisture. This can be prevented by storing food in covered tins.
2. Cooking in shallow uncovered pans will cause greater evaporation and are used for preparing mawa from milk

28. Melting Point

The temperature at which a solid melts and turns into a liquid is called its melting point. The melting point of fats depends on the percentage of saturated long chain fatty acids present in it. The melting point for any chemical is fixed and is used to measure the purity of a substance. It is lowered by adding other substances.

Applications of Melting Point

1. Ice has a melting point of 0 °C. If adequate sodium chloride is added to ice, the melting point falls to –18 °C. This lowering of melting point is used in the setting of ice cream.

29. Food Rheology

It is the science of measuring forces, which are needed to deform food materials or to study the flow properties of liquid foods. Liquid foods are fluid or viscous. Viscosity is defined as the resistance of a liquid to flow. It is measured by an instrument called a viscometer. This property of a liquid is seen in batters, sauces, syrups, etc.

30. Convenience foods

Processed foods in which much pre-preparation/preparation has already been done by the manufacturer, e.g., frozen green peas, breakfast cereals, and canned foods.

31. Hygroscopic Readily absorbing water, such substances are used as drying agents, e.g., silica gel and calcium chloride.

32. Relative humidity Method of measuring the moisture present in air relative to saturation at the same temperature.

33. Rendering The process of removal of fat from the fat cells of adipose tissue of animals by dry heat method.

34. Polymerization of oil: Polymerization occurs during frying, producing a wide variety of chemical reactions that result in the formation of compounds with high molecular weight and polarity . Polymers can form from free radicals or triglycerides by the Diels–Alder reaction.

LESSON-2
BASIC SI UNITS OF LENGTH, AREA, VOLUME AND WEIGHT

The S.I. (Metric) System: Types, Units, and Symbols

All measuring systems have basic units for length, mass (weight), capacity (volume), and temperature. The basic units for the metric system are shown in Table 1.

Table 1: Basic metric units

Type of Measurement	Unit	Symbol
length (distance)	metre	m
mass (weight)	gram	g
capacity (volume)	litre	L
temperature	degrees Celsius	°C

Units of Length (Distance)

The basic unit of length or distance in the metric system is the metre. The most frequently used units of length used in the food industry are the centimetre and millimetre. The units of length in the metric system are shown in Table 3.

Table 3: Metric units of length

Unit	Abbreviation	Length (Distance)
kilometre	km	1000 meter
hectometre	hm	100 metres
decametre	dam	10 metres

metre	m	1 metre
decimetre	dm	0.1 metres
centimetre	**cm**	**0.01 metres**
millimetre	**mm**	**0.001 metres**

Units of Mass (Weight)

The basic unit of mass or weight in the metric system is the gram. The most frequently used units of mass or weight used in the food industry are the gram and kilogram. The units of mass in the metric system are shown in Table 4.

Table 4: Metric units of mass (weight)

Unit	**Abbreviation**	**Mass (Weight)**
tonne	t	1000 kilograms
kilogram	**kg**	**1000 grams**
hectogram	hg	100 grams
decagram	dag	10 grams
gram	**g**	**1 gram**
decigram	dg	0.1 g
centigram	cg	0.01 g
milligram	mg	0.001

Units of Capacity (Volume)

The basic unit of volume or capacity is the litre. The most commonly used units in cooking are the litre and the millilitre. The units of volume in the metric system are shown in Table 5.

Table 5: Metric units of volume

Unit	**Abbreviation**	**Volume**
kilolitre	kL	1000 L
hectolitre	hL	100 L

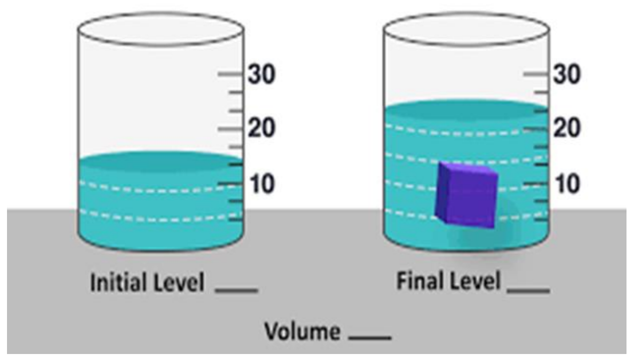
decalitre	daL	10 L
litre	**L**	**1 L**
decilitre	dL	0.1 L
centilitre	cL	0.01 L
millilitre	**mL**	**0.001 L**

Most measuring cups and jugs are marked in millilitres and litres. The capacity of cups and spoons is listed below.

1 tablespoon = 15 ml	1 coffee cup = 100–120 ml
1 teaspoon = 5 ml	1 teacup = 150–180 ml
1 breakfast cup = 240 ml	1 water glass = 280–300 ml

The volume of solids that is not greatly affected by water can be measured by the water displacement method.

Solids are immersed in the displacement can and the volume of water displaced, equal to the volume of the solid, is noted.



The seed method is used to measure the volume of cake and bread. A large tin box is flled to the brim with seeds and the volume of seeds required to fll the box is measured in a measuring cylinder.

The cake, whose volume is to be measured, is placed in the empty tin and covered with seeds. The volume of seeds remaining after covering the cake is equal to the volume of the cake

Density:

Density is one of the most important mechanical properties and thus is widely used in process calculations and product characterization. It is defined as mass per unit volume:

Density= Mass /Volume. SI unit of density is kg m-3

Relative Density

Relative density (RD) is the ratio of the mass of a known volume of a substance to the mass of the same volume of water.

It tells us the number of times the volume of a substance is heavier or lighter than an equal volume of water.

If the RD of a volume of lead is 11, it means that it is eleven times as heavy as an equal volume of water.

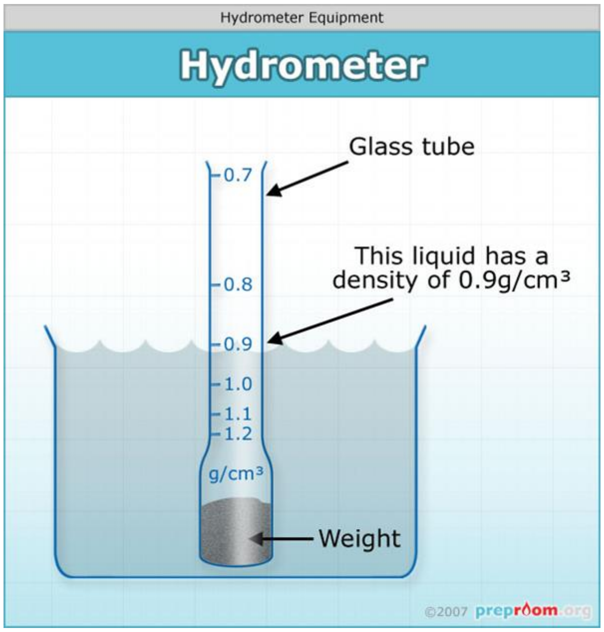
A hydrometer is used to measure the relative density of different liquids.

It is made up of a weighted bulb with a graduated stem calibrated to measure the relative density of the liquid directly.

The liquid is kept at room temperature and the hydrometer is allowed to float in the liquid.

The depth to which it sinks is read on the graduated stem.

Hydrometers are specifically calibrated to measure the RD of different liquids used in the catering industry.



Saccharometers are used to determine the concentration of sugar solutions, denoted in degrees Brix. A 75 per cent sugar solution is called 75 degrees Brix.

Salinometers are used to determine the RD of brine or sodium chloride solutions used for canning vegetables or pickling ham.

Lactometers are used for checking the purity of milk. Addition of water or removal of cream affects the RD and is depicted on the graduated scale on the stem. The scale is marked 1.00 to 1.04. 'W' denotes RD of water, 'M' denotes pure milk, and 'S' denotes skim milk.

Alcoholometers are used to test the RD of alcoholic beverages. It is used to check the number of degrees proof or ethanol content of wines, beers, and spirits, and whether it has been diluted.

Refractometers (see Fig. 1.2) are used to measure the sugar or total solids in solution (TSS) while preparing jam, syrups, etc. They measure the refractive index of light reflected through the solution.

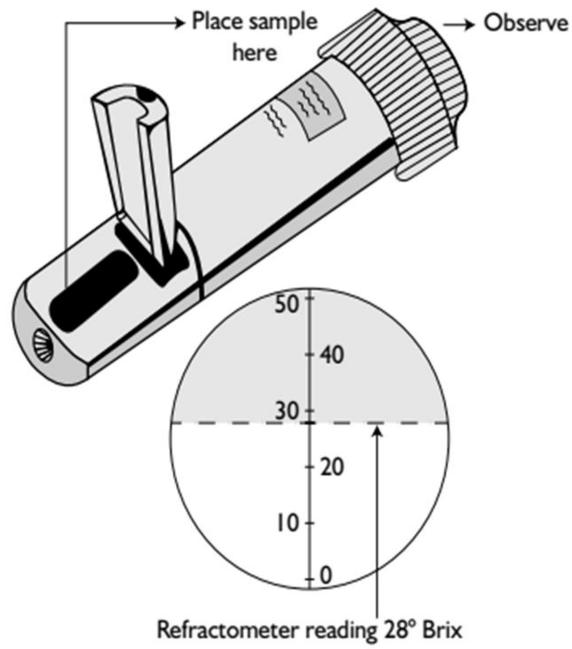


Fig. 1.2 A refractometer

TEMPERATURE

Heat is a form of energy needed to carry out work. Energy is the capacity for doing work. Energy is present in two forms:

1. Potential energy or stored energy, such as the energy stored in a bar of chocolate
2. Kinetic energy or active energy in motion, such as when a person is walking

Energy is present in many forms. Heat is one form of energy. Solar energy, electrical energy, and chemical energy are some of the others.

Heat energy is measured in units called joules and the energy present in food is measured in kilocalories. One kilocalorie is made up of 1,000 calories.

$$1 \text{ kilocalorie (kcal)} = 4.2 \text{ kilojoules (kj)}$$

$$1 \text{ calorie} = 4.2 \text{ joules}$$

Temperature refers to the relative hotness or coldness of a substance compared with melting ice at 0 °C and boiling water at 100 °C. Thermometers are used to measure temperature.

Temperature is measured either in the Celsius or centigrade scale (°C) or in the Farenheit scale (°F). Each scale has two fixed points:

1. Melting point of ice (0 °C or 32 °F)
2. Boiling point of water (100 °C or 212 °F)

The Celsius scale is divided into 100 degrees and the Farenheit scale into 180 degrees. The Celsius scale is the international scale.

Conversion of Farenheit Scale to Celsius Scale

To convert temperature in °F into °C, the following formula is used

$$(°F - 32) \times \frac{5}{9} = °C$$

To convert 212 °F into °C

$$(212°F - 32) \times \frac{5}{9} = \overset{20}{\cancel{180}} \times \frac{5}{\cancel{9}^{1}} = 20 \times 5 = 100°C$$

so $$212°F = 100°C$$

Conversion of Celsius Scale to Farenheit Scale

To convert temperatures in °C to °F, the following formula is used.

$$°C \times \frac{9}{5} + 32 = °F$$

PH of foods

Acid foods are foods that contain enough acid to have a pH of 4.6 or lower. They include fruits, pickles, sauerkraut, jams, jellies, marmalades, and fruit butters. Acidic foods can be processed safely in a boiling water canner, usually without added acid (lemon juice, vinegar or citric acid). This is necessary to control botulinum bacteria. Acidity may be natural, as in most fruits, or added, as in pickled food. Low-acid canned foods are not acidic enough to prevent the growth of these bacteria. Acid foods contain enough acid to block their growth, or destroy them more rapidly when heated. The acidity level in foods can usually be increased by adding lemon juice, citric acid, or vinegar, although this by itself, does not mean the recipe is safe.

Low-acid foods have pH values higher than 4.6 up to 6.9. (non-acidic, or alkaline foods have pH values of 7.0 or greater) .They include red meats, seafood, poultry, milk, and all fresh vegetables except for most tomatoes. Most mixtures of low-acid and acid foods also have pH values above 4.6 unless their recipes include enough lemon juice, citric acid, or vinegar to make them acid food.

LESSON -3

COLLOIDAL CHEMISTRY AS RELATED TO FOODS

Introduction:

Foods are generally complex materials. The properties of their components determine the quality of food. The food components are in the form of solids, in solutions or in the form of colloids - sols or emulsions. These undergo various physical and chemical changes when exposed to different conditions. Knowledge of the scientific principles of these changes is necessary to understand and control the changes occurring in foods during the various aspects of food handling.

Classification and Function of Colloidal Systems in Food:

Foods contain a high percentage of water in which other nutrients present are dispersed. The existence of the colloidal state was first recognized by Thomas Graham (1850), the father of colloidal chemistry. He classified the organic compounds present in foods into two categories:

• Colloids

• Crystalloids

The word colloid, you may be interested to know, is derived from the Greek word "kolla" meaning "glue" and is defined as a system containing particles of size from one millimicron to 0.1 micron (10-6 to 10-4 mm). Colloids are compounds with large molecular weights, which form dispersions only with water. e.g. starch, proteins, glycogen, agar-agar.

Crystalloids, on the other hand, are compounds with small molecular weights, which can form true solutions. e.g. sugars and amino acids.

Solids, liquids and gases may be dispersed in water to form either solutions or colloids.

A solution is a homogenous mixture of two or more different substances. For example salt in water form a solution. This means that the dissolved substances (i.e. salt which is called the solute) and the medium in which they are dissolved (i.e. water which is the solvent) are uniformly distributed throughout the whole of the solution.

A colloidal system, on the other hand, is a heterogeneous system. Colloids are formed when one substance is dispersed through another, but does not combine to form a solution. The material that forms the base of the system is called the dispersion medium or the continuous phase. The material that exists in the colloidal condition is called the dispersed medium or the discontinuous phase. There are many types of colloidal systems depending on the state of the two substances mixed together All three states of matter- gaseous, solid and liquid – may be obtained in the colloidal condition. Ex- Egg white foam is an example of this. Air bubbles (disperse phase) are trapped in the egg white (continuous phase) resulting in a foam.

Thomas Graham referred to colloids as the study of sub microscope dispersion. According to him, it dealt with the dispersed systems of a definite size. Dispersions are classified on the basis of the size of the particles. The particles are dispersed through out the solvent in the form of molecules or ions (molecular dispersion) and it is a one phase system with molecules having dimensions below 1 nm. If the particles range in size from 1 mm to 0.5 mm, they can remain dispersed for a long time without precipitation and constitute a colloidal system. When the size of the dispersed particles is more than 0.5 mm it is termed coarse dispersion or suspension.

Colloidal systems are not restricted to the dispersion of a solid in liquid. Each of the three states of matter - gaseous, solid and liquid – can be dispersed in a medium which may be gaseous, liquid or solid. Accordingly, colloidal systems can be classified based on the physical state of the two phases present: the dispersed phase and the dispersing medium Systems with two phases can occur in eight different combinations, as highlighted in Table 7.1 presenting the classification of colloidal systems.

Colloidal systems in foods can be classified into different groups based on the states of matter constituting the two phases. They are sols, gels, emulsion and foam. Emulsion and foam again can be categorised into solid emulsion/foam and liquid emulsion/foam.

Colloids are formed when one substance is dispersed through another, e.g., sols (a solid is dispersed in a liquid), gels (a liquid held in a solid network, e.g., jam or jelly), emulsions (oily and watery liquids mixed together, e.g., milk and butter), foams (bubbles of gas trapped in a liquid, e.g., whisked egg white or whipped cream), solid foam (bubbles of gas trapped in a solid, e.g., meringue, cake, bread).

The detailed classification of colloidal systems in food is given in Table 2.1.

Table 2.1: Colloidal systems in food

System	Disperse phase	Continuous phase	Product
Sol	Solid	Liquid	Uncooked custard, unset jelly
Gel	Liquid	Solid	Jelly and jam
Emulsion	Liquid	Liquid	Mayonnaise, milk
Solid emulsion	Liquid	Soiid	Butter, margarine
Foam	Gas	Liquid	Whipped cream, whisked egg white
Solid foam	Gas	Solid	Meringue, bread, cake, ice cream

Depending upon the relative affinity of the dispersed phase for the dispersion medium, colloidal dispersions are, further divided into two classes.

• lypophilic (water loving colloids)

• lypophobic (water repelling colloids)

If the affinity between the dispersed phase and the medium is high, the dispersed phase is said to be lyophilic (solvent loving) or hydrophilic, in the case of an aqueous dispersion. Gelatin dispersed in water is an example of a lyophilic colloidal system. Other examples of hydrophilic colloids are biopolymers such as seaweed gums, pectic substances and proteins and hydrophilic complexes found in skim milk, egg yolk and brewed coffee. If the affinity of the dispersed phase to go into or to remain in colloidal dispersion is slight, the dispersed phase is said to be lyophobic (solvent repelling) or hydrophobic when the medium is water. Oil dispersed in water as in the case of butter and margarine, is an example of a lyophobic system. Lyophobic colloids are mainly the aqueous dispersions of inorganic substances rarely recountered in food systems.

Functions of Colloidal Systems in Food Products:

Colloidal systems give structure; texture and mouth-feel to many different food products, for example – Jam, ice cream, mayonnaise. Food colloid contains hydrocolloid that gives stability and rheological properties of food components. An emulsifying agent may be used to help the oil and water phases to mix permanently.

Types of Colloidal System in Food:

(i) Sols and Gels:

A sol can be defined as a colloidal dispersion in which a solid is the dispersed phase and liquid is the continuous phase. Gravy, stirred custard and other thick sauces are some of the examples of sols. When a jelly is made, gelatin is dispersed into a liquid and heated to form a sol. As the solution cools, protein molecules unwind forming a network that traps water and forms a gel.

If corn flour is mixed with water and heated, the starch granules absorb water until they rupture, the starch then disperses in the water and the mixture becomes more viscous and forms a gel on cooling. Other types of gel are formed with pectin and agar. Pectin, a form of carbohydrate found in fruits, is used in the production of jam to help it set.

However, for it to gel there must be at least 50% sugar and conditions should be acidic. Agar is a polysaccharide extracted from seaweed which is capable of forming gels.

(ii) Emulsions:

An emulsion is a mixture of two or more immiscible (they will not mix together) liquids. One liquid (the dispersed phase) is dispersed in the other (the continuous phase), i.e., material that keep fat globules in water droplet or water droplet in fat are emulsifiers. When water and oil are shaken together, they form an emulsion. This emulsion is unstable.

If left to stand, the oil will form a separate layer on top of the water. A stable emulsion is formed when two immiscible liquids are held stable by a third substance, called an emulsifying agent. An emulsion may be oil-in-water (o/w) in which case small oil droplets are dispersed through water, e.g., milk, or water-in-oil (w/o) in which case small water droplets are dispersed through oil, e.g., butter.

(iii) Foams:

Foams are composed of small bubbles of gas (usually air) dispersed in a liquid, e.g., egg white foam. As liquid egg white is whisked, air bubbles are incorporated. The mechanical action causes albumen proteins to unfold and form a network, trapping the air. If egg white is heated, protein coagulates and moisture is driven off. This forms solid foam, e.g., Ice cream, bread and cake are other examples of solid foams.

Stability of Colloidal Systems:

Most colloids are stable. The stability depends on the interaction between the two phases. But the two phases may separate over a period of time because of an increase in the temperature or by physical force.They may also become unstable when frozen or heated, especially if they contain an emulsion of fat and water.

Stability of Sols and Gel in Food:

A sol is a colloidal system in which a solid is dispersed phase and liquid is the continuous phase. The proper ratio of the ingredients is necessary to achieve the desired viscosity of the sols at a certain temperature. Pectin is hydrophilic and attracts a layer of water that is bound tightly to the molecules by hydrogen bonds. So water forms an insulating shield for the pectin providing layers that inhibit bonding between the molecules of the colloidal substances.

Sols can be transformed into gels as a result of reduction in temperature. In pectin gel, the pectin molecules are the continuous phase and the liquid is the dispersed phase while in pectin sol, the pectin molecules are the dispersed phase and the liquid is continuous phase. Sols may be formed as a preliminary step in making a gel. Jams and Jellies Made With Pectin Are Common Examples That Form A Sol Prior To The Desired Structure.

Stability of Emulsion in Food:

An emulsion is a mixture of two or more immiscible (they will not mix together) liquids. One liquid (the dispersed phase) is dispersed in the other (the continuous phase), i.e., material that keep fat globules in water droplet or water droplet in fat are emulsifiers. An emulsion may be oil-in-water (o/w) in which case small oil droplets are dispersed through water, e.g., milk, or water-in-oil (w/o) in which case small water droplets are dispersed through oil, e.g., butter.

An emulsifying agent is made up of two parts. One is hydrophilic (water loving) and the other is hydrophobic (water hating). The emulsifier holds the disperse phase within the continuous phase. This results in the emulsion becoming stable.

Mayonnaise is an example of a stable emulsion of oil and vinegar, when egg yolk (lecithin) may be used as an emulsifying agent. Stabilisers are often added to emulsions to increase the viscosity of the product. These help improve the stability of the emulsion, as over time the emulsion may separate. Stabilisers also increase shelf life, E461 methylcellulose, used in low fat spreads.

Properties of Colloidal Systems

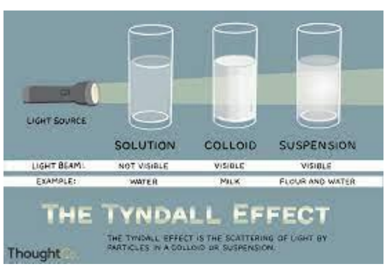
Colloidal systems exhibit certain unique characteristics that help in distinguishing them from solutions.

1. Tyndall Effect

The Tyndall effect is light scattering by particles in a colloid or in a very fine suspension. Also known as Tyndall scattering.

2. Brownian movement

The random motion of small colloid particles dispersed in a liquid or gas medium.



3. Electric Charge

Colloidal particles are electrically charged. Some colloidal particles carry a positive charge (+), others a negative charge (-). The ionic charge is the same for all the charged particles in a given mass of material. This is why colloidal particles remain in suspension: particles with like charges do not clump together because they are repelled by one another

4. Adsorption

Colloidal particles attract and hold to their surfaces the molecules of various gases, vapors and other matter with which they come into contact. This phenomenon is called adsorption. Adsorption plays a very important part in the character of the colloid .By adsorption the particles acquire an electric charge which governs the stability of the colloid. The phenomenon of adsorption finds widespread application in food preparations. For e.g. a too salty soup stock may be made more palatable by the addition of egg white, which when cooked, will gather and hold the salt on to the surface of its particles and settle down to the bottom of the soup vessel.

5. Imbibition

The ability of colloids to pick up water and swell when they come in contact with water is called imbibition. Imbibition is usually accompanied by the evolution of heat and the added materials such as acids and alkalis have a marked effect on the degree of swelling.

LESSON-4

WATER (NEED, USES, SOURCES)

Safe and Wholesome Water

Safe and wholesome water is defined as that which is

- free from pathogenic agents
- free from harmful chemical substances
- pleasant to taste, colourless and odourless
- usable for domestic purposes

If water does not fulfill the above criteria it is said to be polluted or contaminated. Water pollution is a growing ¬hazard in many developing countries owing to human activity. It is not possible to provide positive health to the community without ample and safe drinking water.

Need Of Water

The basic physiological requirement of drinking water for survival has been estimated to be about 2 litres per head per day. But for public health and improvement of the quality of life, water should be provided in adequate volume to reduce the incidence of water-related diseases among the people at risk. The consumption of water depends upon climatic conditions, standard of living, habits of the people, occupation of people and access to water.

Uses Of Water

The uses of water in a community are many, and the requirement in quantity and quality are varied. Conventionally, it has been convenient and economical to provide a single water supply sufficient in quantity to serve all uses and suitable in quality to meet drinking requirements, even though only a small fraction of the total water supply is actually used for drinking.

The Uses Of Water Include:

- Domestic use – water is required for drinking, cooking, washing and bathing, flushing of toilets, gardening etc.
- Public purposes – cleaning streets, swimming pools, public fountains, ornamental ponds, fire protection and public parks
- Industrial purpose – for processing and cooling
- Agricultural purpose – irrigation
- Power Production from hydropower and steam power

- Carrying away waste from all establishments and institutions

Water is therefore an essential factor in the economic, social and cultural development of a community. It can eliminate diseases, promote rural development and improve quality of life.

Sources of Water Supply

In general, water sources must conform to two criteria;

1. The quantity must be sufficient to meet present and future requirement
2. The quality of water must be acceptable.

Main Sources Of Water

1. Rain
2. Surface water

- Impounding reservoirs
- Rivers and streams
- Tanks, ponds and lakes

3. Ground water

- Shallow wells
- Deep wells
- Springs

Main Sources Of Water

Rain Water

Rain is the primary source of all water. A part of the rain water sinks into the ground to form ground water; part of it evaporates back into the atmosphere, and some runs off to form streams and rivers which flow ultimately into the sea. Some of the water in the soil is taken up by the plants and is evaporated in turn by the leaves, the process called "water cycle".

Characteristics of Rain Water:

- Purest water in nature
- Bright and sparkling
- Physically clear
- Chemically soft water containing only traces of dissolved solids (0.0005 per cent)
- Being soft it has a corrosive action on lead pipes.
- Free from pathogenic agents.

Main Sources Of Water

Surface Water

Surface water, main source of water supply in many areas, originates from rain water. Examples of surface water include rivers, tanks, lakes, wadis (water sources which are dry in seasons other than rainy), man-made reservoirs and sea water. Surface water is prone to contamination from human and animal sources. As such it is never safe for human consumption unless subjected to sanitary protection and purification before use.

The vast majority of Indian cities and towns depend upon surface water source, which includes

1. Impounding Reservoirs
2. Rivers and Streams
3. Tanks, Ponds and Lakes.

In general, surface water supplies possess a high probability of organic, bacterial and viral contamination.

1. Impounding reservoirs:

These are artificial lakes constructed usually of earthwork or masonry in which large quantities of surface water is stored. Dams built across rivers and mountain streams also provide large reserves of surface water. The area draining into the reservoir is called "Catchment Area". One disadvantage of storing water for long periods in reservoirs is the growth of algae and other microscopic organisms, which impart bad tastes and odour to water.

Characteristics:

- Clear
- Palatable
- ranks next to rain water in purity
- soft
- Free of pathogenic organisms.

Keep the catchment area free from human or animal intrusion

2. Rivers and Streams:

Many rivers furnish a dependable supply of water. Gross pollution is the major disadvantage of river water and is many times unfit for drinking without treatment.

Characteristics:

- Turbid during rainy season, may be clear in other seasons.
- Contains dissolved and suspended impurities of all kinds
- The bacterial count may be very high.

3. Tanks, Ponds and Lakes:

Tanks, an important source of water supply in Indian villages, are large excavations in which surface water is stored.

Characteristics:

- Receive all types of contamination.
- Full of silt and colloidal matter
- Contain aquatic vegetation (older tanks)

Tanks are thus subjected to unlimited possibilities of contamination and are highly dangerous, as a source of drinking water, even at the best of times. Unfortunately, the tank water is used without being boiled, disinfected or treatment of any kind. This leads to an array of diseases, sickness and death especially of children.

Sea water

Though this source is plentiful, it has great many limitations. Sea water contains 3.5 per cent salts. Off¬shore waters of the oceans and seas have a salt concentration of 30,000 to 36,000 mg/litre (30-36g/litre) of dissolved solids including 19,000 mg/litre of chloride, 10,600 mg/litre of sodium and 1270 mg/litre of magnesium. Desalting and demineralization process involves heavy expenditure. It is adopted in places where sea water is the sole source available.

Ground Water

Ground water is the rain water which percolates to the ground. Water used by humans comes mainly from land. It is now realized that there is a limit to ground water in the world. We should withdraw only quantities of water that can be renewed.

Ground water is the cheapest and most practical means of providing water to small communities. Ground water is superior to surface water because the ground itself provides an effective filtering medium.

Wells: Traditionally wells are an important source of water supply and even today it is true in many communities. Technically wells are of two kinds ¬shallow and deep.

1. Shallow wells: Shallow wells tap subsoil water i.e. the water from above the first impervious layer-in the ground. They yield limited quantities of water and it is most liable to pollution unless care is taken in well construction.

2. Deep wells: A deep well is one which draws water from the water bearing stratum below the first impervious layer in the ground. Deep wells are usually machine-dug and may be several hundred meters in depth. Deep wells provide the safest water and are often the most satisfactory source of water supply.

Sanitary well: A sanitary well is one which is properly located, well-constructed, protected against contamination with a view to supply of safe water.

Tube Wells : Source of drinking water in many parts of India, yield bacteriologically safe water and are cheap compared to other sources. Shallow tube wells or driven wells have become the largest individual source of water supply to the rural community. The area within 15 m of the tube well should be kept free from pollution with liquid and solid wastes.

Springs: When ground water comes to the surface and flows freely under natural pressure it is called a "spring" which may be shallow or deep. Shallow springs dry up quickly during summer months whereas deep springs do not show seasonal fluctuations in the flow of water. Springs are exposed to contamination unless protected by well-built structures to safeguard water quality.

LESSON-5

WATER AND ELECTROLYTE BALANCE

Water is considered as the most important nutrient for the body and forms the greatest component of the human body, making up 50% to 60% of its weight.

Lean muscle tissue contains about 73% water. Fat tissue is about 20% water. Thus as fat content increases in the body, total body water content declines towards 50%.

Without water, life processes would cease in a matter of days and the most abundant substance in the human body. Water – the most versatile medium for all kinds of chemical magic- constitutes the major portion of our bodies.

Without water, our life processes would cease in a matter of days. We operate on about 2 liters of water daily, and it should be replenished daily because the body does not store water well.

The water content of soft tissues ranges from 70 to 80 per cent while that of bone about 20 per cent.

Body water is distributed as follows: (i) inside the cells of tissue – intracellular water (50 per cent) and (ii) outside the tissue cells – extracellular water (20 per cent). The extra cellular water is further sub divided into (i) water in blood plasma (about 4 per cent); (ii) interstitial water – water in tissue space (9 per cent) and (iii) Lymph in the lymphatic vessels (7 per cent).

Functions –

In the human body water performs the following functions:

- regulates body temperature
- carries nutrients throughout the body
- improves digestion
- eliminates waste and toxins from the body

Water makes up two-thirds of the human body and is essential for life. Water helps the body maintain a constant temperature by acting as a thermostat. When a person is in a hot environment the body sweats, and when the sweat evaporates, it lowers the body temperature and restores homeostasis.

As a solvent for nutrients water delivers the nutrients to cells, while it also helps the body eliminates waste products from the cells. Both the spaces between cells (intercellular spaces) and the spaces inside cells (intracellular spaces) are filled with water. Water lubricates joints and acts as shock absorbers inside the eyes and spinal cord. Amniotic fluid, which is largely water, protects the fetus from shock.

Water is an important vehicle for ridding the body of waste products in the form of urine.

Water intake and loss

Loss of water from the body is continuous. The body loses water

(i) via kidney as urine; (ii) via the skin in the form of insensible perspiration and as sweat; (iii) via the lungs in the expired air; (iv) to a small extent via the large intestines in the faeces and (v) in lactating women in the milk. Water is taken in food and also as drinking water. In addition, water is formed in the tissues by the oxidation of hydrogen present in fats, carbohydrates and proteins.

Water intake: Water is taken as drinking water, about 1500 ml (in temperate climate) in food, 1000 ml; and from oxidation of carbohydrates, fats and proteins in tissues, 300 ml.

Water loss: The body loses water through urine, about 1500 ml; via skin 800 ml; via lungs 400 ml and in faeces 100 ml. In a normal individual, the water intake is approximately equal to water lost from the body and thus the water content of the body is maintained fairly constant.

Sources of Water

The amount of water in a human body depends on

- Age
- Gender
- Body type
- Level of physical activity.

The body of an infant up to about twelve months of age, contains about 58 percent water; the bodies of children six to seven years of age is made up of about 62 percent water; bodies of teenage boys contain about 59 percent water; while in teenage girls the water content is about 45 percent. The body of an adult male is approximately 62 percent water, while an adult female is 51 percent water. Physically active individuals generally have more water in their bodies than those who are less physically active. Because they sweat more, active people need to replenish water more often, thus raising their water level. A trained male runner may have up to 71 percent water in his body, while a female gymnast may have 70 percent. Obese individuals, on the other hand, have a lower percentage of water in their bodies (about 48%) because they have higher percent of fatty tissue. Morbidly obese individuals have only about 36 percent water. During old age, less water is retained in body cells. As a result, old skin looks drier and wrinkles appear.

Water Balance

Water balance refers to the balance between the amount of water consumed and the amount of water excreted. For optimal functioning of the body, it is essential that the water content of the body should be maintained constant. Body fluids contain solutes (chemical compounds that are soluble in water), which separate into charged particles, or ions, when dissolved in water. Intracellular fluids are high in potassium and phosphate ions, while interstitial fluids are high in sodium and chloride ions. These ions help to maintain the amount of fluids both within and outside the cells. Water molecules follow the solutes moving across cell membranes from a lower to higher solute concentration to maintain homeostasis.

LESSON-6
CARBOHYDRATES

Introduction

There is more carbohydrate (CHO) material than all other organic material in nature. This is due to the fact that carbohydrates make up most of the organic structure of all plants, as well as, being present to some extent in all animals. Carbohydrates from the major part of the diet and provide 60 – 70 % of the energy in Indian diets. They are found in a wide range of foods. In plants, carbohydrates are synthesized by the photosynthetic process in the presence of sunlight. All carbohydrates are made up of carbon, hydrogen and oxygen and have twice as many hydrogen atoms as oxygen and carbon.Carbohydrates are sometimes referred as Saccharides, which has its origin from the Greek word Sakchron meaning sugar. The simplest carbohydrates are called sugars (or monosaccharides) and these may link together to form more complex carbohydrates (oligo- or poly-saccharides).

Classification

Carbohydrates are classified based on the number of saccharide unit as:

- Monosaccharides or simple sugars – glucose, fructose, galactose.
- Disaccharides or compound sugars – sucrose, maltose, lactose
- Oligosaccharides- Raffinose, stachyose
- Poly saccharides or complex carbohydrates – starch, glycogen, dextin, cellulose, pectin

Table: Classification of carbohydrates

Class	**Examples**	**Some** food sources
Monosaccharides	• Glucose (dextrose, blood sugar) • Fructose (levulose, fruit sugar) • Galactose	• bread, rice, pasta, potatoes, vegetables, fruit, sugar • Fruits, honey, vegetables, corn syrup • Occurs only from the digestion of lactose
Disaccharides	• Sucrose • Maltose • Lactose	• Sugar cane, sugar beet maple sugar, small amounts in fruits and some vegetables • Cereal malts and sprouted legumes, fermented doughs • Milk
Polysaccharides	• Starch • Glycogen (animal starch) • Dextrin • Cellulose	• Grains and grain products, legumes, potato and other root vegetables, green banana • Liver and muscle of animals • Partial breakdown of starch by heat or in digestion

	• Pectin	• Bran of cereal grains, skins and fibre of fruits and vegetables • Guava, apple, wood apple

Monosaccharides

Monosaccharides are the simplest carbohydrate molecules. The most commonly occurring monosaccharides in food are glucose, fructose and galactose. The formula for glucose is $C_6H_{12}O_6$

1. **Glucose:** This monosaccharide is also called dextrose or grape sugar. It is widely distributed in nature and found in fruits, vegetables and cell sap. It is the most abundant carbohydrate found in corn sugar and is present in corn syrup, honey and molasses. In the animal body it is an end product of digestion of starch, sucrose, maltose and lactose. Glucose is the carbohydrate found in the blood of all animals and man where it serves as source of instant fuel or energy for the body. Glucose is oxidized in the body to produce energy. The normal blood glucose level should be 80 – 100 mg/dl. D-5

2. **Fructose:** This is also a monosaccharide and is also known as levulose or fruit sugar. It occurs in fruits and honey. Fructose consumed in the diet is rapidly converted into glucose in the body.

3. **Galactose:** Galactose does not occur in the free state in common foods. It occurs in combination with glucose in lactose (a disaccharide) present in milk. During digestion, when milk is made into curds, glucose is converted into lactic acid and galactose is left behind. Galactose can be converted into glucose in the body and vice versa.

Disaccharides

Disaccharides are formed when two monosaccharide molecules join together withthe elimination of one molecule of water. They have the general formula $C_{12}H_{22}O_{11}$.Examples of disaccharides are sucrose (glucose and fructose), lactose (glucose andgalactose) and maltose (2 molecules of glucose).

1. **Sucrose**: Sucrose occurs in large amounts in sugarcane, palm juice (palm sugar) and beet root (beet sugar). It occurs along with glucose and fructose in several fruits. On hydrolysis, it gives a mixture of glucose and fructose known as invert sugar.

2. **Lactose:** It occurs in human milk (7 %) and in the milk of other animals (mammals) (Cow's milk and buffalo's milk 4 %). It is formed by the combination of one molecule each of glucose and galactose in the mammary gland. Lactose is hydrolysed in digestive tract into glucose and galactose.

3. **Maltose:** This occurs in malt prepared from germinated cereal grains. On hydrolyses it gives two molecules of glucose.

Polysaccharides

Polysaccharides, on the other hand, are made up of many monosaccharide molecules (usually glucose), joined together. They have the general formula ($C_6H_{10}O_5$) n where 'n' is a large number. Examples of polysaccharides are starch, glycogen, cellulose, beta glucan, pectin etc.

1. **Starch:** Plants store carbohydrates in the form of starch and it is the main source of nourishment for human race.It contains two polymers composed of **glucose** units: amylose (linear) and amylopectin (branched). Cereal grains, seeds, roots like potato, tapioca, yam, colocasia and plantain contain considerable amount of starch. On cooking starch absorbs water and it swells and ruptures. This thickening quality of starch is used in cookery to produce a variety of dishes. Starches from different sources are used in cookery to produce a variety of dishes. Different sources of starch behave differently. Maize starch and corn flour are better 'thickening agents' than rice or wheat starch. All cooked starches are broken down into glucose in the digestive system.We often think of potatoes as a "starchy" food, yet other plants contain a much greater percentage of starch (potatoes 15%, wheat 55%, corn 65%, and rice 75%)

2. **Dextrin:** When starch is partially broken into fragments either by digestion or by acids the compounds called dextrins are formed. Dextrin on further hydrolysis is broken down into maltose.

3. **Pectin:** It is a polysaccharide with no nutritional significance. It has jellying characteristic and is useful in the preparation of jam and jelly. It contributes to the palatability of foods.

4. **Glycogen:** Animals store carbohydrate in the body as glycogen. It is stored in the liver and muscles. This is the form of immediate energy for the body. It is also known as animal starch.

5. **Cellulose:** It is an insoluble, indigestible polysaccharide. More than 3000 glucose units are there in cellulose but it is not of human utilization. Cattle can digest cellulose. Even though it is not of much food value it provides bulk to the diet and thus helps in movements of the large intestine. It prevents constipation and to an extent, cancer of the bowel. It helps in reducing the cholesterol level in blood as well as body weight. A high fibre diet can help in the treatment of obesity as it delays digestion and contributes satiety to obese people.

The Functional Role of Sugars in Foods

Sweetness

Sweetness is the most recognized functional property of sweeteners. Our preference for sweetness, regarded as innate, is apparent soon after birth and prior to postnatal learning and decreases with older age. Sweetness is also associated with feelings of pleasure and appreciation or reward, which contribute to the appeal of sweet foods. The combination of sugars and fats in confections provide a sweet taste and texture that compliment each other. In beverages, sucrose provides sweetness without altering the subtle flavours of the beverage.

Carbohydrates differ in sweetness based on composition and source and may be ranked in decreasing order of sweetness as fructose, sucrose, glucose, lactose, dextrin and starch. Raw fruits are bland in taste as they contain starch which is broken down into simple sugars during the ripening process with development of sweet taste. The relative sweetness of sugars is given in table.

Table: Comparative sweetness of sugars

Sugar	**Sweetness value**
Fructose	173
Invert sugar	130
Sucrose	100
Glucose	74
Galactose	32
Maltose	32
Lactose	16

Texture:

In bakery applications, sugars are used to impart flavour, aroma and colour. During the mixing process, excess gluten development can make doughs and batters rigid and tough. Addition of sugar will ensure that gluten maintains an optimal elasticity, allowing the dough to expand and rise properly. During mixing, flour protein is surrounded with water, forming gluten strands. The strands have thousands of balloon-like pockets that trap gases produced during leavening (a process used to produce fermentation in dough or a liquid). These gluten strands are highly elastic, and allow the batter to stretch as the gases expand. Sugars compete for water with gluten proteins, inhibiting their development and allowing proper volume and tender texture. Sugars allow the dough to rise at an optimal rate during leavening. The naturally occurring irregular surface texture of the sugar crystals encourages yeast growth and effectiveness by providing an immediate and easily accessible source of nourishment.

Under appropriate conditions, the yeast cells break down the sugar crystals, releasingcarbon dioxide that causes the dough to rise. Addition of shorteners (fat/oils) to thedough allows the air to get trapped in the naturally irregular sugar crystals. As theshortening and sugar are creamed together, the trapped air cells get interspersed inthe mixture. During baking, these air cells expand with carbon dioxide and other gasesfrom the leavening agents to ensure just the right volume. The sugars naturally interactwith proteins from the beaten eggs to stabilize the foam structure. This makes the eggfoam more elastic, allowing it to expand as it takes up gases from the leavening process.

In bakery products, sugar is recrystallized as water is removed during baking, resultingin a crisp texture. This crispness is increased by the effects of browning (maillardreaction), which takes place when reducing sugars and nitrogen-containing ingredients(e.g. protein) are heated together.

Preservation

In many products, sugars play an important role in preservation. The addition of monosaccharides, such as glucose or fructose, to jams and jellies inhibits microbial growth and subsequent spoilage. Sugars have a great affinity for water, thus slowing moisture loss in foods, like baked foods and extending the shelf-life of these products.

Both honey and invert sugar help to retain moisture due to their high fructose content, as do sorbitol (sucrose alcohol) and corn syrup. Sugars are added to canned vegetables both to maintain firmness and minimize oxidation when the can is opened. Inhibiting oxidation reactions not only protects against deterioration of texture and flavour, but also the loss of colour resulting from the breakdown of pigments. The interaction between sugars and water controls the moisture in products like cakes and biscuits, to prevent drying out and staleness.

Appearance

The browning reactions are complex reactions which occur when foods are processed. In some, the brown flavour is highly desirable and is intimately associated in our mind with the delicacy of the product. In coffee, maple syrup, the brown crust of bread and all baked goods, potato chips, roasted nuts and many other processed foods controlled browning is necessary.

Two major types of non-enzymatic browning reactions have been recognized to occur in foods during processing. These reactions include:

1) Maillard Reaction: reaction of aldehyde and ketone groups of sugars with amino compounds (mostly amino acids, peptides, proteins), independent of the presence of oxygen.

2) Caramelization: the change which occurs in polyhydroxycarbonyl compounds (sugars and sugar acids) when they are heated to high temperature independent of the presence of oxygen.

LESSON-7

NUTRITIONAL ROLE OF CARBOHYDRATES

Functions

Carbohydrates have many important functions in the body.

1. Energy supply

The most important function of carbohydrate is to supply energy or fuel for the body. Glucose is readily utilized by the body for energy needed for physical activities and also for the body cells. The brain, nerve tissues, and erythrocytes are dependent on the constant supply of glucose from the blood to meet their energy needs. Each gram of carbohydrate provides 4 kcals of energy.

2. Carbohydrates as reserve fuel

Carbohydrate in the form of glycogen is stored in liver and muscle including heart muscle. It is used for muscular exercise especially in emergency.

3. Protein sparing action

If carbohydrate supply in the diet is adequate, protein is spared for its important functions. This effect by carbohydrate is called protein sparing effect. Insufficient intake of carbohydrates forces amino acids to be de-aminated and converted to fatty acids for energy purpose.

4. Carbohydrate for fat metabolism

Carbohydrates are needed for complete and normal metabolism of fats, thus preventing acidosis.

5. Carbohydrate for non essential amino acid synthesis

Carbohydrate provides the carbon skeleton for the synthesis of non essential amino acids in the body.

6. Carbohydrate for immunity

Carbohydrates are an important part of some compounds such as immune polysaccharides which increase resistance of the body to infection.

7. Carbohydrates in nucleic acids and other compounds

Carbohydrates and their derivatives form part of nucleic acid such as DNA and RNA and metabolic compounds such as galactolipids, chondroitin sulphate and galactosides.

8. Detoxifying function of carbohydrates

Carbohydrates have protective and detoxifying action in liver. The liver is protected against bacterial toxins by producing glycuronic acid or acetyl groups from carbohydrates which are excreted through kidneys. For this purpose glycogen is used. Thus carbohydrates play a significant role in removing poisonous substances from the liver.

9. Lactose as probiotics

Carbohydrates, especially lactose help the growth of desirable bacteria in the small intestine and help the synthesis of some B-complex vitamins in the intestinal tract.

10. Lactose-calcium absorption

Lactose also helps in the absorption of calcium.

Carbohydrates in the diet

Carbohydrates provide flavour and variety to the diet. Cellulose and other indigestible polysaccharides add bulk to the diet and helps in intestinal motility. Carbohydrates are needed to prevent dehydration.

Benefits of carbohydrate foods

In their natural state Carbohydrates foods have many benefits

- They are high in fibre

- Low in fat
- Good sources of vitamins and minerals

Carbohydrates and health

The blood of a normal healthy human body contains about 80-100 mg of glucose per 100ml. Insulin, the hormone secreted by the beta cells of pancreas help in regulating the blood glucose level. In persons suffering from the disease, Diabetes mellitus, There is insufficient secretion of insulin and hence the concentration of glucose in the blood may be very high (180-300 mg/100ml of blood), depending on the severity of the disease and this condition is known as hyperglycaemia and glucose is excreted (up to 5 percent) in the urine (Glucosuria).
The two forms of Diabetes mellitus are Insulin dependent and Non-insulin dependent (NIDDM). The symptoms include fasting blood glucose levels above 140 mg/100ml of serum, frequent urination (Polyuria), thirst (Polydypsia), extreme hunger (Polyphagia), rapid weight loss, blurred vision, or a sudden change in vision, easy tiring, drowsiness, and general weakness.

Another carbohydrate disorder is low blood glucose levels or Hypoglycaemia, in which the blood glucose level drops to 40-60 mg per 100 ml of blood. This problem comes in two forms-reactive and fasting. Reactive hypoglycaemia is characterized by irritability, nervousness, headache, sweating and confusion 2-4 hours after a meal, especially one high in simple sugars. It may be caused due to overproduction of insulin by the pancreas in response to the rising blood glucose levels. The fasting hypoglycaemia is usually caused by a cancer in the pancreas which can lead to excessive insulin secretion. The blood glucose falls to low levels after fasting for about a day. This form of hypoglycaemia is, however, very rare.

An intake of 50 to 100 grams of carbohydrate prevents ketosis. If carbohydrate consumption is inadequate, the body can make what it needs to support cell metabolism. However, if inadequate carbohydrate continues for weeks at a time, it results in loss of body protein, ketosis and in turn, a general weakening of the body. If excess carbohydrate is consumed for a long period, it will contribute towards obesity and diabetes.

Simple carbohydrates in the form of sugars as present in candies, sweets, toffees etc when consumed in excess, can be metabolized into acids by bacteria on teeth. The acid can erode the tooth surface leading to dental caries.

Dietary fibre

Dietary fibre is primarily a polysaccharide that differs from starch in the linkage between the sugar units. Even after cooking, these links cannot be digested by the human enzymes in the small intestine. This prevents the absorption of sugars that make up the dietary fibre. Dietary fibre is not a single compound but a group of compounds with similar characteristics. The group consists of the carbohydrates cellulose, hemicelluloses, pectins, gums and mucilages as well as the non-carbohydrate lignins, which are alcohol derivatives.

Dietary fibre is classified as

1. **Insoluble dietary fibre** – does not dissolve in water and do not get digested by bacteria in the large intestine example: cellulose, some hemicelluloses and lignins, and

2. **Soluble dietary fibre** – fibre that either dissolve or swell in water and are metabolized by bacteria in the large intestine, these include pectins, gums, mucilages and some hemicelluloses.

A reasonable level of dietary fibre intake in the average Indian vegetarian diet is about 45-50 grams per day. This will help in controlling the blood cholesterol level and also in preventing the problem of colon cancer. Very high dietary fibre intake for example 75-80 grams per day can pose some health risks. A very high fibre intake requires a high water intake. Not consuming enough water with dietary fibre can leave the stool very hard, making it difficult and painful to eliminate. Large amount of dietary fibre can also bind some important minerals especially calcium, iron and zinc making them less available to the body.

Carbohydrate metabolism is the whole of the biochemical processes responsible for the metabolic formation, breakdown, and interconversion of carbohydrates in living organisms.

Glycolysis

Glycolysis is the process of breaking down a glucose molecule into two pyruvate molecules, while storing energy released during this process as ATP and NADH. Nearly all organisms that break down glucose utilize glycolysis. In some tissues and organisms, glycolysis is the sole method of energy production. This pathway is common to both anaerobic and aerobic respiration.

Glycolysis consists of ten steps, split into two phases. During the first phase, it requires the breakdown of two ATP molecules.[1] During the second phase, chemical energy from the intermediates is transferred into ATP and NADH. The breakdown of one molecule of glucose results in two molecules of pyruvate.

Gluconeogenesis

Gluconeogenesis is the reverse process of glycolysis. It involves the conversion of non-carbohydrate molecules into glucose. The non-carbohydrate molecules that are converted in this pathway include pyruvate, lactate, glycerol, alanine, and glutamine. This process occurs when there are lowered amounts of glucose. The liver is the primary location of gluconeogenesis, but some also occurs in the kidney.

This pathway is regulated by multiple different molecules. Glucagon, adrenocorticotropic hormone, and ATP encourage gluconeogenesis. Gluconeogenesis is inhibited by AMP, ADP, and insulin.

Glycogenolysis

Glycogenolysis refers to the breakdown of glycogen. In the liver, muscles, and the kidney, this process occurs to provide glucose when necessary. A single glucose molecule is cleaved from a branch of glycogen, and is transformed into glucose-1-phosphate during this process. This molecule can then be converted to glucose-6-phosphate, an intermediate in the glycolysis pathway.

Glucose-6-phosphate can then progress through glycolysis. Glycolysis only requires the input of one molecule of ATP when the glucose originates in glycogen. Alternatively, glucose-6-phosphate can be converted back into glucose in the liver and the kidneys, allowing it to raise blood glucose levels if necessary.[2]

Glucagon in the liver stimulates glycogenolysis when the blood glucose is lowered, known as hypoglycemia. The glycogen in the liver can function as a backup source of glucose between meals. Adrenaline stimulates the breakdown of glycogen in the skeletal muscle during exercise. In the muscles, glycogen ensures a rapidly accessible energy source for movement.[2]

Glycogenesis

Glycogenesis refers to the process of synthesizing glycogen. In humans, excess glucose is converted to glycogen via this process. Glycogen is a highly branched structure, consisting of glucose, in the form of glucose-6-phosphate, linked together. The branching of glycogen increases its solubility, and allows for a higher number of glucose molecules to be accessible for breakdown. Glycogenesis occurs primarily in the liver, skeletal muscles, and kidney.

Pentose phosphate pathway

The pentose phosphate pathway is an alternative method of oxidizing glucose. It occurs in the liver, adipose tissue, adrenal cortex, testis, milk glands, phagocyte cells, and red blood cells.[6] It produces products that are used in other cell processes, while reducing NADP to NADPH. This pathway is regulated through changes in the activity of glucose-6-phosphate dehydrogenase.[7]

Fructose metabolism

Fructose must undergo certain extra steps in order to enter the glycolysis pathway. Enzymes located in certain tissues can add a phosphate group to fructose. This phosphorylation creates fructose-6-phosphate, an intermediate in the glycolysis pathway that can be broken down directly in those tissues. This pathway occurs in the muscles, adipose tissue, and kidney. In the liver, enzymes produce fructose-1-phosphate, which enters the glycolysis pathway and is later cleaved into glyceraldehyde and dihydroxyacetone phosphate.

Galactose metabolism

Lactose, or milk sugar, consists of one molecule of glucose and one molecule of galactose. After separation from glucose, galactose travels to the liver for conversion to glucose. Galactokinase uses one molecule of ATP to phosphorylate galactose. The phosphorylated galactose is then converted to glucose-1-phosphate, and then eventually glucose-6-phosphate, which can be broken down in glycolysis.

Glycemic Index and Glycemic Load

Increasingly, scientific evidence is confirming that both the quantity and the quality of dietary carbohydrates, proteins, and fats in the diet contribute to how much and how fast blood glucose (sugar) rises after foods are consumed. Glycemic index (GI) and glycemic load (GL) are two objective ways of measuring blood sugar response to foods.

Glycemic Index

The glycemic index (GI) of a food is a numerical ranking, on a scale of 0 to 100 of the extent to which a food will raise blood sugar after eating it. The glycemic index compares the rise in blood sugar level after eating a particular food to a reference food, often the sugar glucose (glucose is a very basic sugar and not the same as table sugar). One of the foods that is often used as a reference food is white bread. It has a relatively high glycemic index of 70 when compared to glucose, which has an index of 100. A high glycemic index may be considered to be a number between 70 and 100; medium, between 50 and 70; and low, under 50.

Glycemic load (GL)

The glycemic index of a particular food can be a useful value to understand the relative ranking of different foods, but does not accurately reflect the effect on blood sugar of an actual serving of food. This is where the glycemic load (GL) comes in. The GL combines both the quality and the quantity of carbohydrate into one value. GL is a more accurate way to predict the impact on blood glucose of different types and amounts of food. For example, watermelon has a high GI (72-80), but a low GL (4-5) because there isn't a lot of sugar in a serving of watermelon, since it is mostly water and fiber. One serving of watermelon (120 grams) only contains 6 grams of carbs. A GL below 10 is considered "low", from 11 to 19 "moderate", and above 20 is "high"

Low GI Foods (20-49)

Breakfast Cereals:
All Bran All Bran Fruit' n Oats
Fiber One Oat Bran
Oatmeal(not instant)

Fruits and Fruit Juices: (Limit 1-2 Fruits/day)
Apples, Apple juice
Apricots Blackberries
Blueberries Cherries
Cranberries (not dried)
Grapefruit Grapefruit juice
Peaches Pears Prunes
Plums Raspberries
Tangerine Strawberries
Tomato juice

Beans and Legumes:
black eyed peas, butter beans chick peas, green beans, kidney beans, pinto beans, lentils, lima beans, navy beans, snow peas, hummus

Non- starchy vegetables:
asparagus, artichoke, avocado, broccoli, cabbage, cauliflower, celery, cucumber, eggplant, greens, lettuce, mushrooms, peppers, tomatoes, okra, onions, spinach, summer squash, zucchini, turnips.

Grains:
barley, rye, bulgur, wild rice, wheat tortilla, wheat pasta

Nuts, olives and oils:
almonds, peanuts, pecans, sunflower seeds, hazelnuts, olives walnuts, oils that are liquid at room temperature

Dairy, fish, meat, soy and eggs:
skim milk, soy milk, almond milk, lowfat cheese, yogurt (lowfat or greek) lean red meat, fish, skinless chicken and turkey, shellfish, egg whites, egg yolks(up to 3/week) soy products, Egg Beaters

Moderate GI Foods(50-69)

Breakfast cereals:
Bran Buds Bran Chex
Just Right Mini Wheats
Special K Swiss Museli

Fruits:
Banana (under ripe) figs
grapes kiwi
Mango oranges
raisins
Cranberry juice, orange juice

Beans and legumes:
boston type baked beans
canned pinto, kidney or navy beans, green peas

Vegetables:
beets, carrots, Sweet potato, yam, corn on the cob

Breads:
pita pocket oat bran bread
pumpernickel bread rye bread
wheat bread high fiber bread

Grains:
cornmeal
brown and white rice
couscous

Pasta:
macaroni
ravioli (meat filled)
pizza (cheese)
spaghetti (white)

Nuts:
cashews
macadamia

Snacks:
chocolate
muffins
low fat ice cream
popcorn

High GI Foods : (70-100)

Breakfast cereals:
Cheerios Corn Flakes
Corn Chex Cream of wheat
Grape Nuts Grape Nut Flakes
Grits Puffed wheat and rice
Rice Chex Rice Krispies
Raisin Bran Shredded Wheat
Total

Fruits:
Dried Dates Pineapple
Watermelon Over ripe bananas

Beverages:
soda, sweet tea, pineapple juice

Vegetables:
potato, baked, broiled, fried, mashed, french fries
canned or frozen corn, parsnips, winter squash

Breads:
most breads (white and whole grain), baguette, bagels, bread sticks, Kaiser roll, dinner roll

Grains:
rice, instant, tapioca

Snacks:
candy, crackers, chips, cookies, syrups, jelly, jam Donuts, corn chips, tortilla chips, pretzels, jelly beans, rice crackers, pastries, cakes, nutragrain bars, Pop tarts.

Restaurant and Ethnic Foods:
Most Chinese food (sugar in stir fry sauces)
Teriyaki meats and vegetables,
Fried rice

Mexican foods with white rice, tortilla, etc

Any foods with white sugar or white flour

The **glycemic index**, or **GI index** is the measurement of how foods raise our blood glucose after eating them. Foods raise glucose to varying levels (carbs increase blood sugar the most, fats and protein second). Actual (sugar) has a glycemic index of 100 and other foods measured are ranked as low, moderate and high GI foods. Although GI index is helpful to meal planning. **The TOTAL number of grams of carbohydrate can have a bigger impact than GI index on blood sugar levels.**

Consuming low GI foods + calculating carbohydrate intake = the most stable blood sugar levels!!!

Lesson - 8

PROTEINS

Introduction:

The name" protein" was suggested by Mulder in that 1838 to the complex organic nitrogenous substances found in animal and plant tissues play an important role in many biochemical and biophysical, physiological processes in the body. Most of the enzymes are proteins. Proteins constitute 20 percent of our body weight. They perform a wide variety of functions throughout the body as vital components of body tissues, enzymes, and immune cells.

Proteins are complex molecules comprised of a combination of different amino acids, which are the building blocks of proteins that contain carbon, oxygen, hydrogen, nitrogen and sulfur and some also contain phosphorus. Amino acids link together in specific numbers and unique combinations to make each different protein. The nitrogen content of protein is about 16%.

Classification of proteins:

The classification of proteins according to the recommendations of the American Physiological Society and the American Society of Biological Chemists are given below:

Simple proteins: Proteins which yield only amino acids or their derivatives on hydrolysis.

Albumins: soluble in pure water and coagulable by heat.
Ex: egg albumin, serum albumin (blood)

Globulins: Insoluble in pure water, but soluble in neutral salt solutions.
Examples: serum globulin (blood), tuberin (potato), arachin and conarachin (groundnut).

Glutelins: Insoluble in all neutral solvents, but soluble in very dilute acids and alkalis. The best known protein of this group is the glutenin of wheat.

Prolamins: Soluble in 70-80 per cent alcohol.

Examples: gliadin (wheat) and zein (maize)

Fibrous proteins: Proteins characteristic of the skeletal structures of animals and also of the external protective tissues, such as skin, hair, etc.

Examples: collagen, elastin and keratin.

Histones: Soluble in water and insoluble in very dilute ammonia. On hydrolysis they yield several amino acids, among which the basic ones predominate. The important members of this group are the thymus histones and the globin of haemoglobin.

Protamins: Strongly basic proteins of low molecular weight, soluble in water, not coagulable by heat and on which yield large amounts of basic amino acids on hydrolysis.

Examples: Salmine from salmon sperm.

Conjugated Proteins: Proteins united to some other molecule otherwise than as a salt.

a. Nucleoproteins: Compounds of proteins with nucleic acid.

b. Glycoproteins: Protein molecule combined with a carbohydrate group.
Example: Mucins.

c. Phosphoproteins: Proteins in which phosphrorus is in union with the protein molecule. Examples: Caseinogen milk,ovovitelin (Egg yolk).

d. Haemoglobins: Protein molecule combined with haem.
Example: Haemoglobin of blood.

e. Lecithoproteins: Protein molecule combined with lecithin or related substances.

Derived Proteins:

1. **Primary Protein Derivatives**: Derivatives of the protein molecule apparently formed through hydrolytic changes which involve only slight alterations.

a. Proteins: Insoluble products which apparently result from the incipient action of very dilute acids or enzymes.
Example: Casein (curdled milk), fibrin (coagulated fibrinogen.

b. Metaproteins: Products resulting from the action of aids and alkalis whereby the molecule is sufficiently altered to form proteins soluble in weak acids and alkalis, but insoluble in neutral solvents.

c. Coagulated proteins: Insoluble proteins which result from 1. the action of heat on protein solutions or 2. The action of alcohol on the proteins.
Example: Cooked egg albumin, or egg albumin precipitated by alcohol.

2. **Secondary Protein Derivatives:** Products of the further hydrolytic cleavage of the protein molecule.

a. Proteases: Soluble in water, not coagulable by heat, precipitated by saturating their solutions with ammonium sulphate.

b. Peptones: Soluble in water not coagulable by heat and not precipitated by saturating their solutions with ammonium sulphate. These represent a further stage of cleavage than the proteoses (the term 'peptone' is generally used to all protein digestion products not coagulated by boiling and containing a mixture of proteases, peptones and peptides).

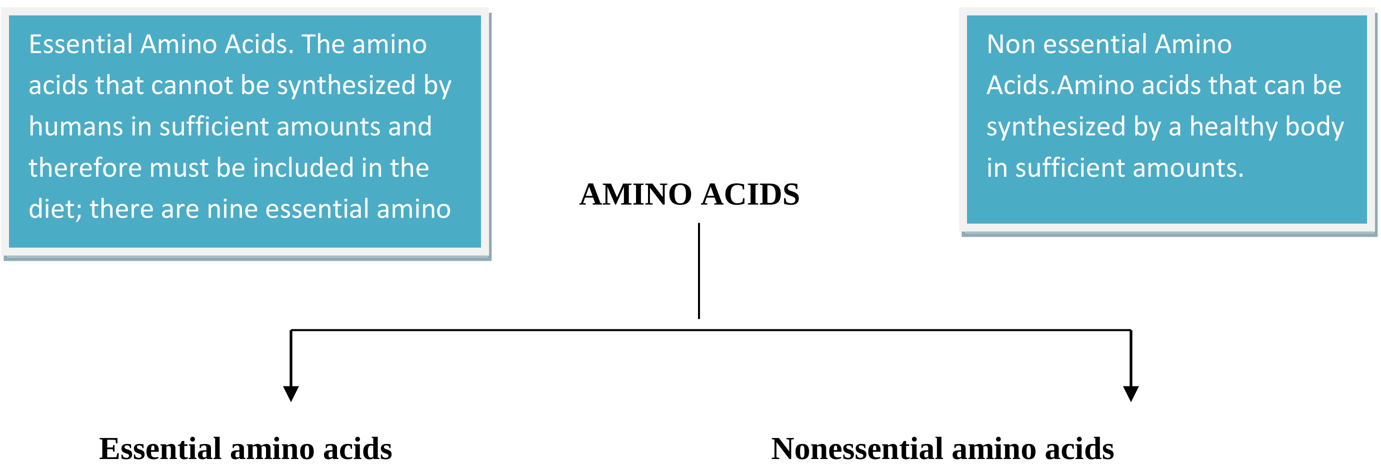
c. Peptides: These are compounds containing two or more amino acids. An anhydride of two amino acids is called a dipeptide, one having three amino acids, a tri – peptide and one containing several amino acids, a polypeptide. Peptides result from the further hydrolytic cleavage of the peptones.

Amino acids:

The percentage of individual amino acids present in different proteins varies from one another. The amino acids naturally occurring in proteins have been broadly classified are given below:

Class	**Examples**
Monoamino-monocarboxylic acids	Glycine, Alanine, Valine, Leucine,Isoleucine , Serine
Monoamino- dicarboxylic acids	Aspertic acid, Glutamic acid
Diamino-monocarboxylic acids	Arginine, Lysine
Sulphur containing amino acids	Cystine, Cysteine, Methionine.
Aromatic and heterocyclic amino acids	Phenylalanine, Tyrosine, Histidine, Tryptophan, proline, Hydroxyproline.

NUTRITIONAL CLASSIFICATION OF AMINO ACIDS:



Essential amino acids

The amino acids that are to be supplied through diet are called as essential amino acids. They cannot be produced by the body. The essential amino acids are arginine, valine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine and tryptophan.

Arginine and histidine are called semi-essential amino acids as they can be partly synthesized in the human body.

Arginine is not essential for infants.
Arginine and Histidine are not essential for adults.

Nonessential amino acids

The amino acids that can be synthesized by the body are called non essential amino acids. They are: Glycine, alanine, serine, cysteine, aspartic acid, glutamic acid, aspargine, glutamine, tyrosine and proline.

NUTRITIONAL CLASSIFICATION OF PROTEINS:

Group	Limiting essential amino acid

i). Complete proteins: promote good growth in rats and other animals e.g. Egg, meat, fish	Nil
ii). Partially complete proteins: promote moderate growth. e.g. Wheat proteins **iii).** Incomplete proteins: Do not promote growth. e.g., Gelatin or Zein.	Particularly lacking in one or more essential amino acids. Completely lacking in one or more essential amino acids.

Food Sources of Proteins

Food protein sources can be divided into 3 major categories:

a) Protein of animal origin,

b) Protein of plant origin

Proteins of Animal Origin

1) Meat: Skeletal or striated muscles are used for food purposes. Flesh of cattle, sheep and swine comprise most of the meat contents. Edible meat from these is designated as Red Meat, a term descriptive of colours of beef, lamb or pork, as opposed to the light and dark colours of poultry meat. The red colour is primarily due to myoglobin. A typical adult mammalian muscle stripped of all external fat contains about 18-22% proteins on wet weight basis.

2) Milk: A value of 3.5% protein is often considered as an average for milk. Milk protein has traditionally been divided into 2 classes – casein and whey protein. Casein is a heterogenous group of phosphoprotein, which can be precipitated from raw skimmed milk by acidification at pH.14.6 and 20.0

C. Proteins remaining

In solution after casein precipitation are called 'whey proteins' (or milk serum proteins). Casein fraction consists of about 80% of total protein content, rest is whey protein. Whey fraction mainly consists of β-lactalbumin, α-lactalbumin, immunoglobulins, bovine serum albumin etc.

3) Eggs: Roughly, the chicken egg consists of 11% shell, 31% yolk and 58% white. Liquid whole egg consists of 65% white and 35% yolk. Yolk appears to be the initial source of food, while egg white seems to act as a protective barrier, prior to its eventual use as a source of protein.

4) Fish: Fish usually contains 40-60% edible flesh. Protein content of fresh water fishranges from 13-25%. 5) Shellfish: Information on shellfish is fragmentary and incomplete.

b) Proteins of Plant Origin

Vegetable proteins, cereal proteins, nuts and seed proteins come from the plantorigin.

1) Vegetable Proteins: Fresh vegetables are not considered to be a very good source of proteins. On fresh weight basis, the average protein content of somecommon vegetables are: carrots and lettuce-1%, white potatoes, asparagus andgreen beans-2% and fresh peas-6%.

Although protein content of potatoes is only 2%, quality is considered to be goodto excellent due to relatively high content of the amino acids – lysine andtryptophan.

2) Cereal Proteins: Cereal grains, properly ripened and dried for optimum storagestability, have protein content ranging from 6-20%. In the milling of grain (eg. wheat), theendosperm is essentially separated from the bran and germ and then pulverizedto produce flour, which is used as food. Endosperm proteins apparently act as astructural component and also as food reserves for the growing seedlings.

3) Seed Proteins: Although a large number of plants produce seeds having proteincontents in excess of 15%, only a few are utilized for food, eg. soybean, peas, peanuts and beans. Proteins of seeds are largely concentrated inprotein bodies.

4) Nuts: Nuts are excellent sources of proteins. Examples of nuts include cashewnuts, almond nuts , hazel nuts , coconuts, walnuts, brazil nuts, pistachio nuts etc. Some nuts like almonds contain complete proteins. Those nuts that do not containcomplete proteins can be extremely useful sources of proteins if they are eatenin combination with other protein foods, or with milk or cheese, or with vegetables

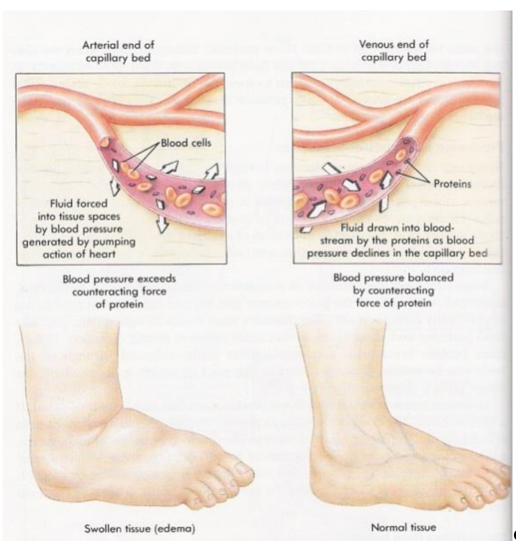
LESSON - 9

PROTEINS

FUNCTIONS:

Protein which provides 4 calories per gram, is an important source of energy for the body, when carbohydrates and fats are not available. In addition to using protein to generate energy for cellular function whenever necessary, the body uses the amino acids contained in the protein we eat to manufacture its own proteins. The proteins synthesized by the body perform a variety of important physiological functions:

- **Production and maintenance of structural proteins**: The body manufactures several structural proteins, such as myosin, actin, collagen, elastin, and keratin, that maintain the strength and integrity of muscles, connective tissues (ligaments and tendons), hair, skin, and nails.
- **Production of enzymes and hormones**: All of the enzymes, which are compounds that catalyze chemical reactions in the body, are made from protein. In addition, the hormones involved in blood sugar regulation (insulin and glucagon) as well as the thyroid hormones are synthesized from proteins.
- **Production of transport proteins and lipoproteins**: Certain proteins are used by the body to carry various substances to body tissues. These transport proteins include hemoglobin (carries oxygen), transferrin (carries iron), ceruloplasmin (carries copper), retinol-binding protein (carries vitamin A), albumin and transthyretin (both carry other proteins). Lipoproteins participate in the transportation of fat and cholesterol.
- **Maintenance of proper fluid balance:** Proteins participate in the maintenance of osmotic pressure, which controls the amount of water that is found inside of cells.



SOURCE: WARDLAW etal.

FIGURE: Blood proteins are important for maintaining the body's fluid balance. Without sufficient protein in the bloodstream, edema develops.

Production of antibodies: Antibodies, which are proteins, play an important role in the immune system by attaching to antigens (viruses, bacteria, or other foreign invaders), thereby inactivating the antigens and making them more visible to the immune cells (called macrophages) that destroy antigens.

Maintenance of proper acid-base balance: Due to their ability to combine with both acidic and basic substances, proteins help to maintain the normal acid-base balance in the body.

Properties of Proteins

1. Denaturation:

Partial or complete unfolding of the native (natural) conformation of the polypeptide chain is known as denaturation. This is caused by heat, acids, alkalies, alcohol, acetone, urea, beta-mercaptoethanol.

2. Coagulation:

When proteins are denatured by heat, they form insoluble aggregates known as coagulum. All the proteins are not heat coagulable, only a few like the albumins, globulins are heat coagulable.

Food Source

Excellent sources of protein include those from animal origin, fish, tuna, shrimp, and cod.

Very good sources of protein include halibut, salmon, chicken, lamb, beef, liver, tofu, egg, soybeans, and cheese.

Good sources of protein include milk and many legumes including lentils, split peas, kidney beans, black beans, pinto beans and garbanzo beans.

Eggs, dairy foods, meat, fish and poultry are typically considered to be complete proteins.

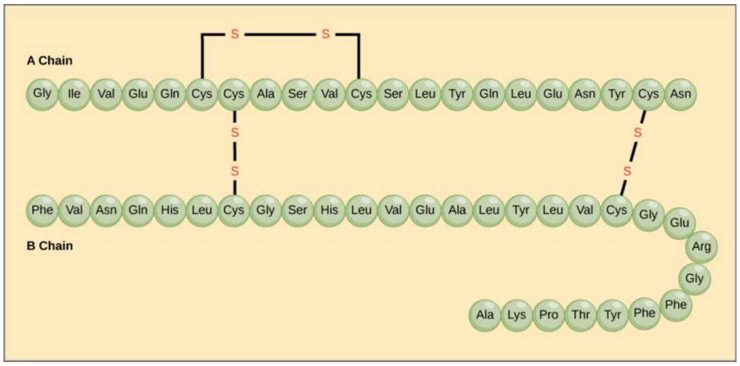
Vegetarians, and especially vegans, often do not have a source of complete protein in their diets, but can easily obtain all of the essential amino acids by eating a variety of legumes, beans, grains, nuts, seeds and vegetables.

Structure of proteins

Primary Structure

• The simplest level of protein structure, primary structure is simply the sequence of amino acids in a polypeptide chain.

• The hormone insulin has two polypeptide chains A, and B. The sequence of the A chain, and the sequence of the B chain can be considered as an example for primary structure.

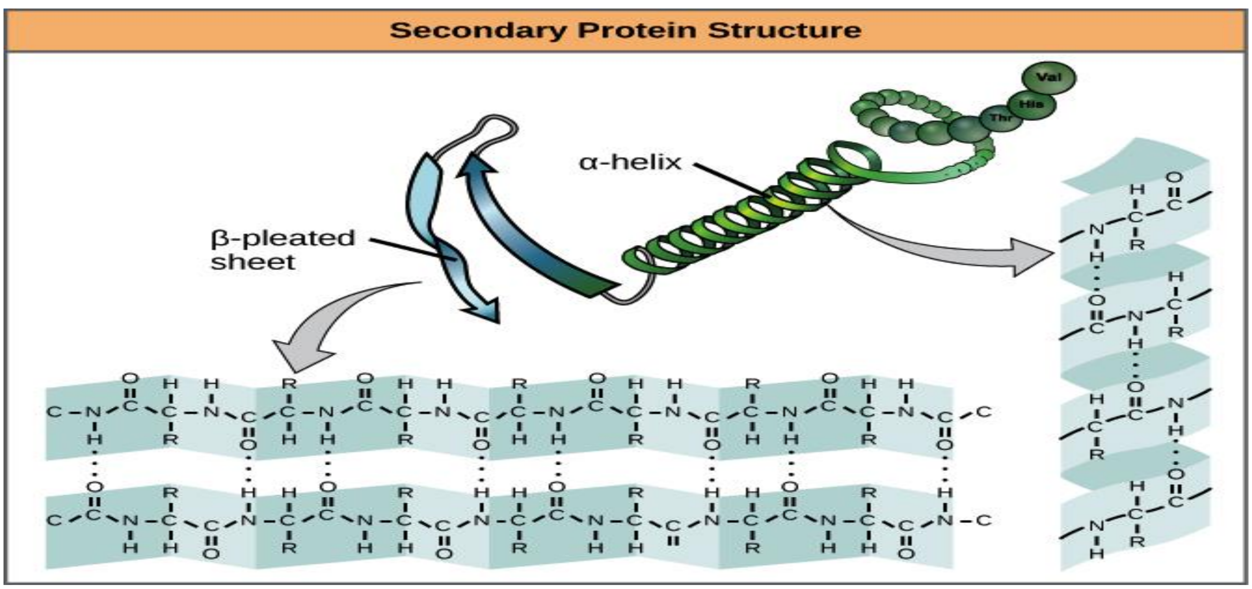


Secondary structure

refers to local folded structures that form within a polypeptide due to interactions between atoms.

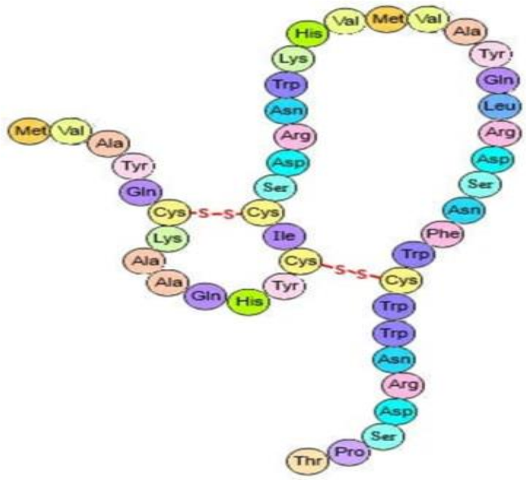
• The most common types of secondary structures are the α helix and the β pleated sheet.

Both structures are held in shape by hydrogen bonds, which form between the carbonyl O of one amino acid and the amino H of another.



Tertiary structure

The overall three-dimensional structure of a polypeptide is called its tertiary structure. The tertiary structure is primarily due to interactions between the R groups of the amino acids that make up the protein.



Quaternary structure

When multiple polypeptide chain subunits come together, then the protein attains its quaternary structure.

• An example for quaternary structure is hemoglobin. The hemoglobin carries oxygen in the blood and is made up of four subunits, two each of the α and β types.

Lesson -10

LIPIDS

Introduction:

Lipids are a group of naturally occurring substances characterized by their insolubility in water, greasy feel and solubility in some organic solvents. They occur widely in the plant and animal kingdom, in the form of oils and fats respectively. The basic structure of lipids is comprised of carbon, hydrogen, and oxygen (sometimes nitrogen and phosphorous are also present).

The lipid (fat) content of food is the major determinant of the energy density of diets. Each gram of fat provides 9.0kcal of energy.

Classification:

Lipids are classified as:

A. Simple Lipids: These are esters of fatty acids and glycerol. Oils are liquids at 20^0 C while fats are solids at 20^0C.

B. Compound Lipids: These lipids contain some other organic compounds, in addition to fatty acids and glycerol they are further categorized as

i. ***Phospholipids (Phosphatides):*** These contain phosphoric acid and nitrogenous base in addition to glycerol and fatty acids. (Lecithin, Cephalins, Plasmalogens).

ii. ***Sphingolipids:*** These contain the base sphingosine or dihydrosphingosine.

iii. ***Glycolipids:*** Complex lipids containing carbohydrates in combination with fatty acids and sphingosine (Cerebrosides, Gangliosides and Cytolipin).

iv. ***Sulpholipids:*** These contain sulphuric acid in combination with hexose in a cerebroside.

C. Waxes: These are ester of fatty acids and long – chain aliphatic alcohols.

D. Derived Lipids: They include fatty acids, alcohols, and sterols.

The lipids present in the diet and also in the animal and human body include:

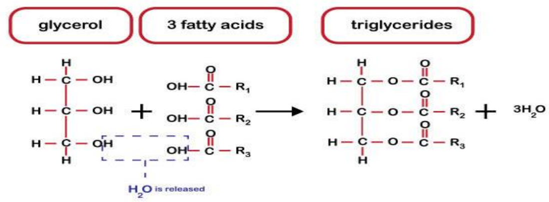
(1) Triglycerids,

(2) Phospholipids and other compound lipids, and

(3) Cholesterol (present only in animal foods).

Triglycerides and fatty acids:

Triglycerides comprise about 95 percent of the lipids in food and in our bodies. They are the storage form of fat. When we eat a high calorie diet, the energy in excess of our energy needs is converted into triglycerides and stored in the body.



Triglyceride

All triglycerides have a similar structure. It is composed of three fatty acids attached to a glycerol molecule. Glycerol is a short-chained carbohydrate molecule that is soluble in water, and when triglycerides are metabolized, the glycerol can be converted to glucose. Fatty acids may differ in their length and their degree of saturation. They are commonly composed of a series of 16–18 carbon molecules attached to hydrogen molecules. The number of hydrogen molecules determines the saturation of the fat. When each carbon has its maximum number of hydrogens attached, the fat is said to be saturated i.e. filled to capacity with hydrogen.

Saturated fats: These are commonly found in animals and are hard (solid) at room temperature. Lard, suet, and butter are common saturated animal fats; coconut and palm oil are two saturated vegetable oils. Saturated fats are generally more stable than unsaturated fats and do not easily become rancid (undergo an oxidative change in molecular structure) .

Saturated Fatty Acid .a fatty acid with no carbon – carbon double bonds.

Saturated Fatty Acid

(Stearic acid)

(Methyl group) (Acid group)

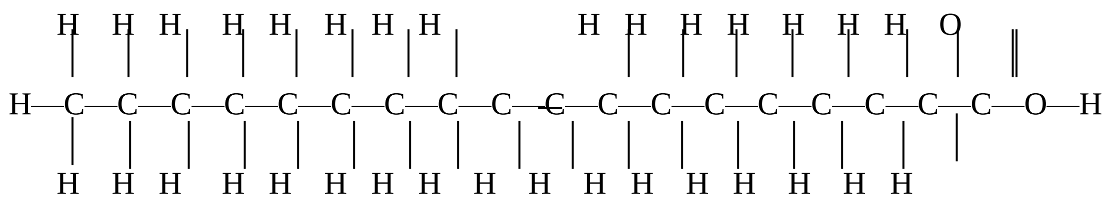
```
   H  H  H  H  H  H  H  H  H  H  H  H  H  H  H  H  H  H
   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  ||
H—C—C—C—C—C—C—C—C—C—C—C—C—C—C—C—C—C—C—O—H
   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
   H  H  H  H  H  H  H  H  H  H  H  H  H  H  H  H  H  H
```

Unsaturated fats: These are of two types—monounsaturated and polyunsaturated. If a fatty acid has one double bond between the carbons, it is **monounsaturated** (Figure B). Olive and canola oils contain a high percentage of monounsaturated fatty acids. If a fatty acid contains two or more double bonds, the fatty acid is **polyunsaturated** (Figure C and D). Linoleic acid, an

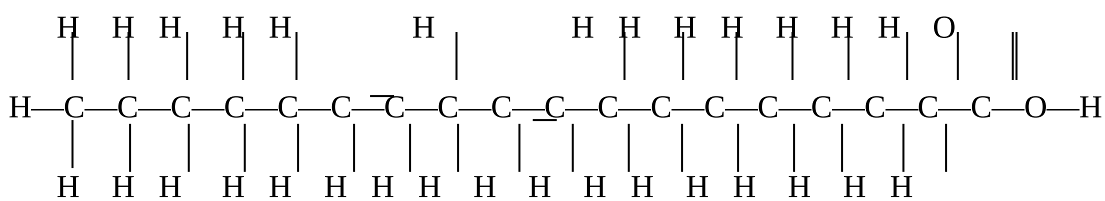
Monounsaturated Fatty Acid: A fatty acid containing one double bond.

essential fatty acid found in safflower oil, soybean oil, and other vegetable oils, is an example of a polyunsaturated fat. Other oils of this category include groundnut oil, corn oil, and cottonseed oil.

Monounsaturated Fatty Acid (oleic acid)



Polyunsaturated Fatty Acid (linoleic acid)



The point at which the double bonds begin in the fatty acid is important. Counting from the end with a CH_3 group if these double bonds start after the third carbon, it is an **omega -3 (ω-3) fatty acid**. If these double bonds start after the sixth carbon, it is **omega-6 (ω-6) fatty acid**, and so on.

Unsaturated fats are unstable at room temperature and sensitive to interaction with oxygen, light, and heat. This is why storage in dark glass containers/bottles or cans and/or under refrigeration is ideal. Besides refrigeration rancidity of an oil can be prevented by 1) use of antioxidants which binds the points of unsaturation i.e the weak spots in the fatty acid, which can be "attacked" by oxygen and protect the molecules from oxidation.) Vitamin E is a common antioxidant; beta-carotene and the chemicals Butylated Hydroxy Anisole (BHA) and Butylated Hydroxy Toluene (BHT) are other antioxidants and 2) hydrogenation.

Essential fatty acids

The term 'Essential fatty acid' (EFA) also known as polyunsaturated fatty acids (PUFA) was introduced by Burr and Burr in 1930 for linoleic acid.

The **essential fatty acids** (EFA) include linoleic, linolenic, and arachidonic acids. They are all polyunsaturated fatty acids that cannot ordinarily be synthesized in the body; although, if sufficient quantities of linoleic acid (omega-6) are present, arachidonic acid can be made.

Essential Fatty Acids: These are fatty acids that must be present in the diet to maintain health; and include linoleic acid and alpha-linolenic acid.

Linoleic acid is necessary for synthesis of prostaglandins. Safflower oil is particularly high in linoleic acid, sunflower and corn oils; other vegetable oils, nuts, and seeds are also good sources. Soybean, flaxseed, canola, as well as pumpkin and walnut are the best sources of alpha-linolenic acid.

Hydrogenation: This is a process involving chemically induced hydrogen saturation of the carbon bonds, by which the structure of unsaturated oils is changed. This alters the way the body metabolizes these fats and often changes the physical form, such in margarine and vanaspathi.

Phospholipids

Phospholipids, are important in the structure of all membranes. Their structure is similar to that of triglycerides, but they contain only two fatty acids (both polyunsaturated). The third molecule attached to the glycerol is a phosphatidylcholine molecule (choline is one of the B vitamins). The most common phospholipid is lecithin. Certain phospholipids also contain inositol (B vitamin) as phosphatidylinositol, as well as phosphatidylethanolamine, another phospholipid that has several functions, such as being a precursor to choline and acetylcholine. Lecithin is found in highest concentration in soybean and egg yolk. Recently, egg lecithin has been used in the treatment of acquired immune deficiency syndrome (AIDS).

Sterols/Cholesterol

Cholesterol, is the precursor of the bile acids and the sex hormones. It is primarily manufactured in the body, although all tissues of the body except the brain can make it. Cholesterol is present in almost all cells and its concentration is particularly high in the liver, brain and nervous tissue, and the blood. Cholesterol, like lecithin, is also available in foods, such as egg yolk, meats, and other animal fats, including milk products. It is not readily available in most vegetable foods.

A transport mechanism of cholesterol called the low-density lipoprotein (LDL) is the likely cause of risk for the cardiovascular disease called atherosclerosis. In this condition, cholesterol in the form of LDL cholesterol accumulates in the inner living of the arteries thereby obstructing free flow of blood. This LDL is contrasted to the so-called “good” cholesterol-carrying high-density lipoprotein (HDL). The ratio of these two (LDL:HDL) is the blood test currently favored to evaluate our risk of cardiovascular disease.

LESSON - 11
LIPIDS

Functions of Fats: Fat has several important functions

- It is a concentrated source of energy yielding more than twice the energy supplied by carbohydrate per unit weight.
- Fat is essential for the absorption of vitamins A, D, E and K and carotenoids.
- Vegetable fats are (with a few exceptions) good sources of vitamin E and red palm oil is a good source of carotene while some animal fats such as butter and fish liver oils are good sources of Vitamin A.
- Certain vegetable fats are rich sources of the essential fatty acid-linoleic acid.
- Fats reduce the bulk of the diet as they provide twice as much calories as carbohydrates per unit weight. Further starchy foods absorb lot of water during cooking and increase the bulk of the diet.
- Fats improve palatability and give a satiety value i.e., a feeling of fullness in the stomach.
- Fats are deposited in adipose tissue and thus serve as a reserve source of energy during starvation, illness, etc. The adipose tissue acts as an insulating material against cold and physical injury.

Properties of fats

1. Solubility: Fats are soluble in organic solvents such as ethyl ether, petroleum ether, acetone and benzene. The quantity of fat present in food materials is usually determined by extraction with ethyl ether or petroleum ether.
2. Saponification Value: (Saponification number): The saponification value is defined as the number of milligrams of potassium hydroxide required to saponify 1 g. of fat or oil.
3. Iodine Value: (Iodine number): It is a measure of the extent of unsaturated fatty acids present in fats and oils. It is defined as the number of grams of iodine absorbed by 100g of fat.
4. Reichert-Meissl Value: This is defined as the number of milliliters of 0.1 N alkali (sodium or potassium hydroxide) required to neutralize the steam volatile water soluble fatty acids present in 5 g. sample of fat. The test determines the amount of butyric acid and caproic acid which are readily soluble in water and a part of caprylic acid which is slightly soluble in water.
5. Thiocyanogen Value: The thiocyanogen number is the amount of thiocyanogen absorbed by 100 grams of fat or oil.

Rancidity in Fats

The development of off-flavours in fats is known as rancidity. There are three main types of rancidity

- Hydrolytic Rancidity

- Oxidative Rancidity
- Ketonic Rancidity

Hydrolytic Rancidity: Hydrolysis of fats by lipase need not always produce off-flavours. In the case of butter fat and coconut oil, butyric acid and other low molecular weight fatty acids are set free on hydrolysis by lipase. The odours of these acids contribute largely to the smell of rancid butter. The higher fatty acids such as palmitic and stearic acids have little odour.

Oxidative Rancidity: This is the common type of rancidity observed in all fats and oils. The oxidation takes place at the unsaturated linkage. Certain metals, such as copper, hasten the onset of oxidative rancidity. The addition of oxygen to the unsaturated linkage results in the formation of a peroxide which, on decomposition, yields aldehydes and ketones having pronounced off odour.

Ketonic Rancidity: This type is most frequently encountered as a result of action of fungi such as Aspergillus niger and blue-green mould, penicillium glaucum on coconut or other oil seeds. The tallow odour developed may be due to aldehydes and ketones formed by the action of the enzymes present in the fungi on oil.

Factors Affecting Rancidity and Reversion:

1. Oxidation:

Oxygen is eight times more soluble in fats than in water and it is the oxidation resulting from this exposure that is the primary cause of rancidity. Oxidation primarily occurs with unsaturated fats by a free radical-mediated process. These chemical processes can generate highly reactive molecules in rancid foods and oils, which are responsible for producing unpleasant and noxious odors and flavors. This process is called auto-oxidation or oxidative rancidity.

2. Hydrolysis:

Triglycerides react with water under appropriate condition to form diglycerides and free fatty acid residues. Diglycerides later combine with water to form monoglycerides and fatty acids. Finally the monoglycerides completely hydrolysed to form glycerol and fatty acids. This process is called hydrolytic rancidity.

3. Presence of Microorganisms – Microbial Lipase:

Certain microorganisms can produce the hydrolytic enzyme called lipase, which directly interferes the hydrolysis of triglcerides and produce glycerols and fatty acid. These fatty acids undergo auto- oxidation to form rancid. The microbial lipase requires suitable pH and other conditions for its activity upon fats and oil.

4. Presence of Unsaturation in Fatty Acid Chain:

When a fatty substance is exposed to air, its unsaturated components are converted into hydroperoxides, which break down into volatile aldehydes, esters, alcohols, ketones, and hydrocarbons, some of which have disagreeable odours. Butter becomes rancid by the foregoing process and by hydrolysis, which liberates volatile and malodorous acids, particularly butyric acid. Saturated fats such as beef tallow are resistant to oxidation and become rancid at ordinary temperatures.

5. Polyunsaturation:

The more polyunsaturated a fat is, the faster it will go rancid. Vegetable oils have to become several times more rancid than animal fats. Presence of polyunsaturation in oils and fats makes them more susceptible to rancidity than monosaturated and other types of saturated fatty acids.

6. Chemical Structure of Oils and Fats:

If oils and fats are chemically more complex and consists more number of double bond, more number of carboxyl or hydroxyl groups, then the chances of become rancid is high. The double bonds found in fats and oils play a role in auto-oxidation. Oils with a high degree of unsaturation are most susceptible to auto- oxidation.

The best test for auto-oxidation (oxidative rancidity) is determination of the peroxide value. Peroxides are intermediates in the auto-oxidation reaction. The peroxide value of oil or fat is used as a measurement of the extent to which rancidity reactions have occurred during storage.

7. Temperature and pH:

These are the important factor which influences the food items rich in fat and oils become rancid. Suitable temperature and alkaline pH are required for the hydrolytic action of microbial lipase. Temperature and pH indirectly influence the auto-oxidation and hydrolysis.

8. Heat and Light:

Presence of heat and light accelerate the rate of reaction of fats with oxygen, i.e., heat accelerates auto-oxidation. Heat and light act as the energy source for the production of free radical in rancidity and reversion of oils and fats.

Prevention of Rancidity:
Rancidity can be prevented by several ways which are mentioned briefly:

1. Addition of Antioxidants:

The best method used to prevent food item from rancidity is the addition of antioxidants. Antioxidants are added to fat-contain-ing foods in order to retard the development of rancidity due to oxidation.

There are five types of antioxidants:

(1) Natural antioxidants.

(2) Synthetic antioxidants.

(3) Semi-synthetic antioxidants – gallic acid, propylgallate.

(4) Metal chelators – citric acid, phos-phoric acid.

(5) Oxygen scavengers – ascorbic acid.

Natural antioxidants include flavonoids, polyphenols, ascorbic acid (vitamin C) and tocopherols (vitamin E). Synthetic antioxidants include butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl-3, 4, 5-trihydroxybenzoate (also known as propyl gallate) and ethoxyquin. Natural antioxidants tend to be short-lived, but synthetic antioxidants give longer shelf life and better action.

The effectiveness of water-soluble antioxidants is limited in preventing direct oxidation within fats, but is valuable in intercepting free radicals that travel through the watery parts of foods. A combination of water-soluble and fat- soluble antioxidants is ideal, usually in the ratio of fat to water.

2. Addition of Sequestering Agents:

Sequestering agents bind metals, thus preventing them from catalyzing auto-oxidation. Examples of sequestering agents include EDTA (ethylene diamine tetra acetic acid) and citric acid.

3. Proper Storage of Fats and Oil Food:

Another method for preventing rancidity of food is the proper storage, keeping away from the action of oxygen. Rancidification can be decreased by storing fats and oils in a cool, dark place with little exposure to oxygen or free radicals, since heat and light accelerate the rate of reaction of fats with oxygen.

Do not add fresh oil to vessels containing old oil. The old oil will trigger a reaction and the new oil will become rancid far more rapidly than, if the oil was stored in a clean empty vessel. Avoid using vessels that are wet, this will also speed up the problems associated with oxidation, allow tanks to drain and dry adequately before use.

Effects of deficiency

Essential Fatty Acid deficiency in Human beings:

Phrynoderma*:* This is one of the common disorders of malnutrition observed in adults and children. The condition is characterized by the presence of horny popular eruptions on the posterior and lateral aspects of the limbs, on the back and buttocks. Phrynoderma is cured rapidly by the administration of linseed or safflower seed oil which are rich in essential fatty acids (EFA) along with B – complex vitamins but not by vitamin A.

Deficiency in Infants:

Hansen and co-workers have reported that infants fed on a EFA deficient diet developed perennial irritation and changes in the skin within a few weeks. The skin changes appeared as dryness, thickening and desquamation with oozing in the intertriginous folds. Supplementation of the diet with linoleic acid restored the skin to normal condition within two weeks.

Sources:

Rich Sources of EFA:Safflower, sunflower, niger seed, cotton seeds, linseed, corn, walnut, sesame and soybean oils are rich sources (40 to 70%) of EFA. These oils must form at least 50% of the fat in the diet.

Good Sources:Rape seed, groundnut and rice bran oils are good sources (27 to 32%) of EFA.

Fair Sources:Egg yolk fat, poultry fat and pig body fat are fair sources (15 to 22%) of EFA.

Poor Sources:Coconut oil, palm kernel oil, vanaspathi (hydrogenated ground oil), butter and ghee, beef and mutton fat are poor sources (3 to 5%) of EFA.

LESSON – 12

VITAMINS

Introduction:

- ✓ Vitamins are natural substances found in plants and animals known to be essential for good health.
- ✓ The name vitamin is obtained from "vital amines" as it was originally thought that these substances were all amines. Human body uses these substances to stay healthy and support its many functions.
- ✓ Vitamins do not provide energy (calories) directly, but they help to regulate energy-producing processes.
- ✓ Vitamins are essential for the normal growth and development of a multi-cellular organism.
- ✓ There are 13 essential vitamins and each one has a special role to play within the body, helping to regulate the processes such as cell growth and repair, reproduction and digestion and metabolism of nutrients and release of energy.

Severe deficiency in one or more of these vitamins during the growth of the foetus/ child results in deficiency disease. **Deficiencies of vitamins** are classified as either primary or secondary.

1. **Primary Deficiency:** A primary deficiency occurs when we do not get the required amount of a vitamin in the food consumed..
2. **Secondary Deficiency:** A secondary deficiency may be due to an underlying disorder that prevents or limits the absorption or use of the vitamin.

Classification of Vitamins

Vitamins are one among the essential nutrients required by the body and can be broadly classified into two main categories based on their solubility

- Water-soluble vitamins

  Water-soluble vitamins travel in the blood and are stored in limited amounts. These are readily excreted from the body through urine.

- Fat-solublevitamins .
  Fat-soluble are stored in the liver and fatty tissues. These are not readily excreted from the body.

Fat-soluble vitamins

- The fat-soluble vitamins include vitamins **A, D, E and K** - since they are soluble in fat and are absorbed by the body from the intestinal tract.
- The human body has to use bile acids to absorb fat-soluble vitamins. Once these vitamins are absorbed, the body stores them in body fat. When required, the body takes them out of storage to be used.
- Eating fats or oils that are not digested can cause shortages of fat-soluble vitamins. These vitamins are not lost on cooking.
- Fat soluble vitamins should not be consumed in excess as they are stored in the body and an excess can result in side effects.
- An excess of vitamin A may result in irritability, weight loss, dry itchy skin in children and nausea, headache, diarrhea in adults.

Characteristics of the vitamins are:

- Most of the vitamins have been artificially synthesized.
- Some vitamins are soluble in water and others are fat-soluble.
- Some vitamins are synthesized in the body. Some members of vitamin B complex are synthesized by microorganisms in the intestinal tract.
- Vitamins are partly destroyed and are partly excreted.
- Vitamins can be stored in the body to some extent, for example the fat-soluble vitamins are stored in the liver and subcutaneous tissue.
- Vitamins can perform their work in very small quantities. Hence, the total daily requirement is usually very small.

Water-soluble vitamins:

- B-complex vitamins and vitamin C are water-soluble vitamins.

- Water-soluble vitamins cannot be stored in the body, so we need to get them from food every day. These are easily absorbed by the body.

- These vitamins are easily destroyed or washed out during food storage and preparation(over cooking). Proper storage and preparation of food can minimize loss of these vitamins. Vitamin loss can be reduced by refrigeration of fresh produce, keeping milk and grains away from strong light, and use of cooking water from vegetables to prepare soups.

- An excess of water soluble vitamins will not result in any side effects as they disperse in the body fluids and are excreted in the urine.

- These vitamins are widely distributed in foods (Table). The B complex group is constituted of eleven water soluble vitamins.

  Nine of the water-soluble vitamins are known as the B-complex group:

B_1 (thiamine)

B_2 (riboflavin)

Niacin (nicotinic acid)

B_6 (pyridoxine)

B_{12}

Folic acid

Pantothenic acid

Biotin

Choline

Para-amino benzoic acid

Inositol

A summary of fat and water-soluble vitamins, their functions, deficiency symptoms and food sources.

Fat soluble vitamins

Vitamin	**Functions**	**Deficiency symptoms**	**Sources**	**Toxicity**
Vitamin A (retinoid) and pro-vitamin A (carotenoids)	Vision in dim light and color vision Promote growth Prevent drying of skin and eyes Promote	Poor growth, night blindness, dry skin(keratinization), Xerophthalmia	Preformed vitamin A: liver, fortified milk, fish liver oils Provitamin A: red, orange, dark green, and yellow vegetables, orange fruits	Headache, vomiting, double vision, hair loss, dry mucous membranes, bone and joint pain, fractures, liver damage, hemorrhage, coma

	resistance to bacterial infection			
Vitamin D (Chole-and ergo-calciferol	Facilitates absorption of calcium and phosphorus Maintains optimum calcification of bone	Rickets in children, osteomalacia in older adults	Egg Yolk, Milk. Exposure to sun enables body to make its own Vitamin D.	Calcification of soft tissues, growth restriction, excess calcium excretion via the kidney.
Vitamin E (Tocopherols Tocotrienols)	Antioxidant, prevent breakdown of vitamin A and unsaturated fatty acids	Hemolysis of red blood cells, degeneration of sensory neurons	Vegetable oils, nuts, green leafy vegetables	Inhibition of vitamin K metabolism.
Vitamin K (Phyllo- and menaquinone)	Synthesis of blood clotting factors and bone proteins	Hemorrhage, fractures	Green leafy vegetables, liver, also synthesized by intestinal microorganisms	No upper level has been set

Water soluble vitamins

Vitamin	Functions	Deficiency symptoms	Sources	Toxicity
Thiamine (vitamin B_1)	Coenzyme involved with enzymes in carbohydrate metabolism; nerve function	Beriberi, Mental confusion, muscle weakness, wasting, oedema, impaired growth.	Pork, liver, whole grains, enriched grain products, peas, meat, legumes.	None known.
Riboflavin (vitamin B_2)	Coenzyme involved in energy metabolism	Cracks at corners of mouth, inflammation of mouth and tongue, dermatitis around nose and lips, eyes sensitive to light.	Liver, milk, dark green vegetables, whole and enriched grain products, eggs.	None known.
Niacin (nicotinamide, nicotinic acid)	Coenzyme involved in energy metabolism, prevent breakdown of	Pellagra, diarrhea, dermatitis, dementia.	Liver, fish, poultry, meat, peanuts, whole and enriched	Abnormal liver function, cramps, nausea, irritability.

	vitamin A and unsaturated fatty acids		grain products.	
Vitamin B_6 (pyridoxine, pyridoxal, pyridoxamine)	Coenzyme involved in protein metabolism, neurotransmitter synthesis, hemoglobin synthesis.	Skin disorders, dermatitis, anemia, irritability, anemia, kidney stones, nausea, sore tongue.	Pork, meats, whole grains and cereals, legumes, green, leafy vegetables.	None known.
Pantothenic acid	Coenzyme involved in energy metabolism, fat synthesis and fat breakdown	Fatigue, nausea, abdominal cramps, difficulty in sleeping.	Liver, kidney, meats, egg yolk, whole grains, legumes; also made by intestinal bacteria.	About half of pantothenic acid is lost in the milling of grains and highly refined foods.
Vitamin B_{12} (cobalamins)	Coenzyme involved in folate metabolism, nerve function.	Pernicious anemia, poor nerve function.	Found only in animal foods: meats, liver, kidney, fish, eggs, milk and milk products, oysters, shellfish.	None known.
Folacin (folic acid)	Coenzyme involved in DNA synthesis.	Megaloblastic anemia, inflammation of tongue, diarrhea.	Liver, kidney, dark green leafy vegetables, meats, fish, whole grains, fortified grains and cereals, legumes, citrus fruits.	May mask vitamin B_{12} deficiency (pernicious anemia).
Vitamin C	Collagen	Scurvy:	Citrus fruits,	Nontoxic under

(ascorbic acid)	synthesis, hormone synthesis, neurotransmitter synthesis; wound healing; absorption of iron, calcium, folacin.	Bleeding gums, poor wound healing, pinpoint hemorrhages, edema.	guava, amla, strawberries, melon, green pepper, tomatoes, dark green vegetables, potatoes.	normal conditions; rebound scurvy when high doses discontinued; diarrhea, bloating, cramps; increased incidence of kidney stones.

LESSON -13
WATER SOLUBLE & FAT SOLUBLE VITAMINS

B-COMPLEX VITAMINS

Eight of the water-soluble vitamins are known as the vitamin B-complex group: thiamin (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3), vitamin B6 (pyridoxine), folate (folic acid), vitamin B12, biotin and pantothenic acid. The B vitamins are widely distributed in foods and their influence is felt in many parts of the body. They function as coenzymes that help the body obtain energy from food. The B vitamins are also important for normal appetite, good vision, and healthy skin, nervous system, and red blood cell formation.

Thiamin:

Vitamin B1, helps to release energy from foods, promotes normal appetite, and is important in maintaining proper nervous system function.

Food Sources for Thiamin

Sources include peas, pork, liver, and legumes. Most commonly, thiamin is found in whole grains and fortified grain products such as cereal, and enriched products like bread, pasta, rice, and tortillas. The process of enrichment adds back nutrients that are lost when grains are processed. Among the nutrients added during the enrichment process are thiamin (B1), niacin (B3), riboflavin (B2), folate and iron.

RDA

Males: 1.2 mg/day; Females: 1.1 mg/day

Thiamin Deficiency

Under-consumption of thiamin is rare due to wide availability of enriched grain products. However, low calorie diets as well as diets high in refined and processed carbohydrates may place one at risk for thiamin deficiency. Alcoholics are especially prone to thiamin deficiency because excess alcohol consumption often replaces food or meals. Symptoms of thiamin deficiency include: mental confusion, muscle weakness, wasting, water retention (edema), impaired growth, and the disease known as beriberi. Thiamin deficiency is currently not a problem in the United States.

Riboflavin:

Vitamin B2 helps to release energy from foods, promotes good vision, and healthy skin. It also helps to convert the amino acid tryptophan (which makes up protein) into niacin.

Food Sources

Sources include liver, eggs, dark green vegetables, legumes, whole and enriched grain products, and milk. Ultraviolet light is known to destroy riboflavin, which is why most milk is packaged in opaque containers instead of clear.

RDA

Males: 1.3 mg/day; Females: 1.1 mg/day

Deficiency

Under consumption of riboflavin is rare. However, it has been known to occur with alcoholism, malignancy, hyperthyroidism, and in the elderly. Symptoms of deficiency include cracks at the corners of the mouth, dermatitis on nose and lips, light sensitivity, cataracts, and a sore, red tongue.

Nicotinamide, Nicotinic Acid Niacin

vitamin B3, is involved in energy production, normal enzyme function, digestion, promoting normal appetite, healthy skin, and nerves.

Food Sources for Niacin

Sources include liver, fish, poultry, meat, peanuts, whole and enriched grain products.

RDA

Males: 16 mg/day; Females: 14 mg/day

Niacin Deficiency

Niacin deficiency is known to occur with alcoholism, protein malnourishment, low calorie diets, anddiets high in refined carbohydrates. Pellagra is the disease state that occurs as a result of severe niacindeficiency. Symptoms include cramps, nausea, mental confusion, and skin problems.

Vitamin B6: Pyridoxine

Pyridoxal, Pyridoxamine Vitamin B6, otherwise known as pyridoxine, pyridoxal or pyridoxamine, aids inprotein metabolism and red blood cell formation. It is also involved in the body's production chemicalsuch as insulin and hemoglobin.

Food Sources for Vitamin B6

Sources include pork, meats, whole grains and cereals, legumes, and green, leafy vegetables.

RDA

The RDAfor vitamin B6 is 1.3 mg/day for adult males and females through age fifty.

Deficiency

Deficiency symptoms include skin disorders, dermatitis, cracks at corners of mouth, anemia, kidneystones, and nausea. A vitamin B6 deficiency in infants can cause mental confusion.

Folate:

Folic Acid, Folacin Folate, also known as folic acid or folacin, aids in protein metabolism promoting red blood cell formation, and lowering the risk for neural tube birth defects. Folate may also play a role in controlling homocysteine levels, thus reducing the risk for coronary heart disease.

Food Sources for Folate

Sources of folate include liver, kidney, dark green leafy vegetables, meats, fish, whole grains, fortified grain and cereals, legumes, and citrus fruits. Not all whole grain products are fortified with folate.

RDA

The RDA for folate is 400 mcg/day for adult males and females. Pregnancy will increase the RDA for folate to 600 mcg/day.

Folate Deficiency

Folate deficiency affects cell growth and protein production, which can lead to overall impaired growth. Deficiency symptoms also include anemia and diarrhea. A folate deficiency in women who are pregnant or of child bearing age may result in the delivery of a baby with neural tube defects such as spina bifida

Vitamin B_{12}

Cobalamin Vitamin B_{12}, also known as cobalamin, aids in the building of genetic material, production of normal red blood cells, and maintenance of the nervous system.

Food Sources for Vitamin B_{12}

Vitamin B_{12} can only be found only in foods of animal origin such as meats, liver, kidney, fish, eggs, milk and milk products, oysters, shellfish. Some fortified foods may contain vitamin B_{12}.

RDA

The Recommended Dietary Allowance (RDA) for vitamin B_{12} is 2.4 mcg/day for adult males and females

Vitamin B_{12} Deficiency

Vitamin B_{12} deficiency most commonly affects strict vegetarians (those who eat no animal products), infants of vegan mothers, and the elderly. Symptoms of deficiency include anemia, fatigue, neurological disorders, and degeneration of nerves resulting in numbness and tingling. In order to prevent vitamin B_{12} deficiency, a dietary supplement should be taken. Some people develop a B_{12} deficiency because they cannot absorb the vitamin through their stomach lining. This can be treated through vitamin B12 injections

VITAMIN C: ASCORBIC ACID

The body needs vitamin C, also known as ascorbic acid or ascorbate. Vitamin C benefits the body by holding cells together through collagen synthesis; collagen is a connective tissue that holds muscles, bones, and other tissues together. Vitamin C also aids in wound healing, bone and tooth formation, strengthening blood vessel walls, improving immune system function, increasing absorption and utilization of iron, and acting as an antioxidant. Since our bodies cannot produce or store vitamin C, an adequate daily intake of this nutrient is essential for optimum health. Vitamin C works with vitamin E as an antioxidant, and plays a crucial role in neutralizing free radicals throughout the body. An antioxidant can be a vitamin, mineral, or a carotenoid, present in foods, that slows the oxidation process and acts to repair damage to cells of the body. Studies suggest that vitamin C may reduce the risk of certain cancers, heart disease, and cataracts.

Food Sources for Vitamin C

Consuming vitamin C-rich foods is the best method to ensure an adequate intake of this vitamin. While many common plant foods contain vitamin C, the best sources are citrus fruits (orange, kiwi fruit, grape etc,

RDA

The Recommended Dietary Allowance (RDA) for Vitamin C is 90 mg/day for adult males and 75 mg/day for adult females For those who smoke cigarettes, the RDA for vitamin C increases by 35 mg/day, in order to counteract the oxidative effects of nicotine.

Vitamin C Deficiency

Severe vitamin C deficiency result in the disease known as scurvy, causing a loss of collagen strength throughout the body. Loss of collagen results in loose teeth, bleeding and swollen gums, and improper wound healing. More commonly, vitamin C deficiency presents as a secondary deficiency in alcoholics, the elderly, and in smokers.

VITAMIN A: RETINO

Vitamin A, also called retinol, has many functions in the body. In addition to helping the eyes adjust to light changes, vitamin A plays an important role in bone growth, tooth development, reproduction, cell division, gene expression, and regulation of the immune system. The skin, eyes, and mucous membranes of the mouth, nose, throat and lungs depend on vitamin A to remain moist.

Food Sources for Vitamin A

Eating a wide variety of foods is the best way to ensure that the body gets enough vitamin A. The retinol, retinal, and retinoic acid forms of vitamin A are supplied primarily by foods of animal origin such as dairy products, fish and liver. Some foods of plant origin contain the antioxidant, betacarotene, which the body converts to vitamin A. Beta-carotene, comes from fruits and vegetables, especially those that are orange or dark green in color. Vitamin A sources also include carrots, pumpkin, winter squash, dark green leafy vegetables and apricots, all of which are rich in beta-carotene.

RD

The recommendation for vitamin A intake is expressed as micrograms (mcg) of retinol activity equivalents (RAE). Retinol activity equivalents account for the fact that the body converts only a portion of betacarotene to retinol. One RAE equals 1 mcg of retinol or 12 mcg of beta-carotene. The Recommended Dietary Allowance (RDA) for vitamin A is 900 mcg/ day for adult males and 700 mcg/ day for adult females. Compared to vitamin A, it takes twice the amount of carotene rich foods to meet the body’s vitamin A requirements, so one may need to increase consumption of carotene containing plant foods. Recent studies indicate that vitamin A requirements may be increased due to hyperthyroidism, fever, infection, cold, and exposure to excessive amounts of sunlight. Those that consume excess alcohol or have renal disease should also increase intake of vitamin A.

Vitamin A Deficiency

Vitamin A deficiency is rare, but the disease that results is known as xerophthalmia. It most commonly occurs in developing nations usually due to malnutrition. Since vitamin A is stored in the liver, it may take up to 2 years for signs of deficiency to appear. Night blindness and very dry, rough skin may indicate a lack of vitamin A. Other signs of possible vitamin A deficiency include decreased resistance to infections, faulty tooth development, and slower bone growth. Vitamin A toxicity The Tolerable Upper Intake Level (UL) for adults is 3,000 mcg RAE. It would be difficult to reach this level consuming food alone, but some multivitamin supplements contain high doses of vitamin A. If you take a multivitamin, check the label to be sure the majority of vitamin A provided is in the form of betacarotene, which appears to be safe. Symptoms of vitamin A toxicity include dry, itchy skin, headache, nausea, and loss of appetite. Signs of severe overuse over a short period of time include dizziness, blurred vision and slowed growth. Vitamin A toxicity also can cause severe birth defects and may increase the risk for hip fractures.

VITAMIN D

Vitamin D plays a critical role in the body's use of calcium and phosphorous. It works by increasing the amount of calcium absorbed from the small intestine, helping to form and maintain bones. Vitamin D benefits the body by playing a role in immunity and controlling cell growth. Children especially need adequate amounts of vitamin D to develop strong bones and healthy teeth.

Food Sources for Vitamin D

The primary food sources of vitamin D are milk and other dairy products fortified with vitamin D.Vitamin D is also found in oily fish (e.g., herring, salmon and sardines) as well as in cod liver oil. In addition to the vitamin D provided by food, we obtain vitamin D through our skin which produces vitamin D in response to sunlight.

RDA

The Recommended Dietary Allowance (RDA) for vitamin D appears as micrograms (mcg) of cholecalciferol (vitamin D3). From 12 months to age fifty, the RDA is set at 15 mcg. Twenty mcg of cholecalciferol equals 800 International Units (IU), which is the recommendation for maintenance of healthy bone for adults over fifty

Vitamin D Deficiency

Symptoms of vitamin D deficiency in growing children include rickets (long, soft bowed legs) and flattening of the back of the skull. Vitamin D deficiency in adults may result in osteomalacia (muscle and bone weakness), and osteoporosis (loss of bone mass).

VITAMIN E: TOCOPHEROL

Vitamin E benefits the body by acting as an antioxidant, and protecting vitamins A and C, red blood cells, and essential fatty acids from destruction. Research from decades ago suggested that taking antioxidant supplements, vitamin E in particular, might help prevent heart disease and cancer. However, newer findings indicate that people who take antioxidant and vitamin E supplements are not better protected against heart disease and cancer than non-supplement users. Many studies show a link between regularly eating an antioxidant rich diet full of fruits and vegetables, and a lower risk for heart disease, cancer, and several other diseases. Essentially, recent research indicates that to receive the full benefits of antioxidants and phytonutrients in the diet, one should consume these compounds in the form of fruits and vegetables, not as supplements.

Food Sources for Vitamin E

About 60 percent of vitamin E in the diet comes from vegetable oil (soybean, corn, cottonseed, and safflower). This also includes products made with vegetable oil (margarine and salad dressing). Vitamin E sources also include fruits and vegetables, grains, nuts (almonds and hazelnuts), seeds (sunflower) and fortified cereals.

RDA

The Recommended Dietary Allowance (RDA) for vitamin E is based on the most active and usable form called alpha-tocopherol. Food and supplement labels list alpha-tocopherol as the unit International units (IU) not in milligrams (mg). One milligram of alpha-tocopherol equals to 1.5 International Units (IU). RDA guidelines state that males and females over the age of 14 should receive 15 mcg of alpha-tocopherol per day. Consuming vitamin E in excess of the RDA does not result in any added benefits.

Vitamin E Deficiency

Vitamin E deficiency is rare. Cases of vitamin E deficiency usually only occur in premature infants and in those unable to absorb fats. Since vegetable oils are good sources of vitamin E, people who excessively reduce their total dietary fat may not get enough vitamin E.

VITAMIN K

Vitamin K is naturally produced by the bacteria in the intestines, and plays an essential role in normal blood clotting, promoting bone health, and helping to produce proteins for blood, bones, and kidneys.

Food Sources for Vitamin K

Good food sources of vitamin K are green, leafy-vegetables such as turnip greens, spinach, cauliflower, cabbage and broccoli, and certain vegetables oils including soybean oil, cottonseed oil, canola oil and olive oil. Animal foods, in general, contain limited amounts of vitamin K.

RDA

Males and females age 14 - 18: 75 mcg/day; Males and females age 19 and older: 90 mcg/day

Vitamin K Deficiency

Hemorrhage can occur due to sufficient amounts of vitamin K. Vitamin K deficiency may appear in infants or in people who take anticoagulants, such as Coumadin (warfarin), or antibiotic drugs. Newborn babies lack the intestinal bacteria to produce vitamin K and need a supplement for the first week. Those on anticoagulant drugs (blood thinners) may become vitamin K deficient, but should not change their vitamin K intake without consulting a physician. People taking antibiotics may lack vitamin K temporarily because intestinal bacteria are sometimes killed as a result of long-term use of antibiotics. Also, people with chronic diarrhea may have problems absorbing sufficient amounts of vitamin K through the intestine and should consult their physician to determine if supplementation is necessary.

LESSON-14

MINERALS

Introduction

Minerals are inorganic elements which are utilized as structural components of tissue and cellular compounds, as catalysts for enzyme activity, and to maintain normal osmotic and electrochemical gradients that support neuromuscular activity and cell membrane transport activity. They constitute less than 5-6 % of total human mass. Mineral elements may be required in small amounts (milligrams) or in trace amounts (micrograms). The body contains about 24 minerals, all of which must be provided by the diet. These include calcium, phosphorus, potassium, sodium, chlorine, magnesium, iron, zinc, bromine, fluorine, nickel, chromium, cadmium, selenium etc.

Functions:

Minerals have three general functions in the body.

- Minerals **maintain electroneutrailty** across cell membranes and help to maintain water balance.
- Minerals are important to the **structural integrity of the skeletal system** and many proteins. Calcium, magnesium, phosphorus, and fluoride are important to bone and teeth. Zinc provides structural integrity to proteins important for DNA transcription.
- Minerals act as **cofactors to many enzymes** and participate as electron carriers in several reactions.

Classification of minerals:

Minerals have been classified **historically** as

- Major minerals
- Trace elements.

Major minerals include compounds that are needed in the diet in amounts greater than 100 mg/day. Animals and humans need major minerals, including sodium, potassium, calcium, magnesium, and phosphorus in large amounts.

Trace minerals, also called as trace elements, are found in the body and required in the diet in small amounts (less than 100 mg/day), although they play important roles in the body. These are iron, copper, iodine, manganese, zinc, molybdenum, selenium and chromium. (fig)

Fig: Role of trace minerals in the body.

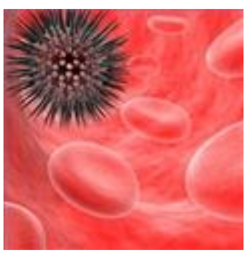
Role of Minerals:

Calcium

1. 

Calcium helps to maintain strong bones and teeth. It is also involved in nerve function and helps in lowering the blood pressure. Calcium is present in milk, yoghurt and other dairy products. Calcium is also found in broccoli, almond, sardines and other small fish eaten along with the bones. Calcium deficiency is characterized by symptoms such as muscle weakness and back pain.

Iron

2. 

Iron is important in red blood cell formation. It is essential in the transportation of oxygen in the body, as well as the formation of red blood cells. A lack of iron in the blood is known as anemia, and symptoms include paleness and weakness. Iron is found in foods such as fish, eggs and liver.

Magnesium

3. 

Magnesium is essential in converting blood sugar into energy, as well as maintaining a normal heart rhythm and regulating blood pressure. It is found in green leafy vegetables, nuts and bananas. Magnesium deficiency is characterized by an irregular heartbeat and kidney stones, among other symptoms.

Zinc

4. 

Zinc is associated in enhancing the immune system while helping maintain growth and development. It is found in leafy vegetables, whole grains and eggs. Zinc deficiency results in symptoms such as hair loss, delayed growth and skin inflammation.

Iodine

5. 

Iodine is essential for development and growth. It helps the thyroid gland to manufacture hormones. Iodine deficiency leads to dry skin, fatigue, and an enlarged thyroid gland. Iodine is present in table salt, seaweed and seafood, such as marine fishes.

Chromium

6. 

Chromium is responsible for stabilizing blood sugar levels and breaking down body fats, lowering 'bad' cholesterol. Chromium deficiency is exhibited through symptoms such as fatigue and mood swings. It is present in red meats, cheese, whole wheat bread, mushrooms etc.

Potassium

7. 

Potassium helps to maintain low blood pressure and to convert glucose (blood sugar) into glycogen, which is a storage form of carbohydrates in the body. Potassium is found in high amounts in fresh fruits and vegetables as well as in nuts. Deficiency is shown in symptoms such as nausea, weakness and excessive thirst.

Sodium

8. 

Sodium is required for normal function of muscles and nerves. Sodium coupled with potassium, helps to regulate fluids in the body. Deficiencies are rare, but are characterized by nausea, dizziness, dehydration and muscle cramps. Sodium is found in shellfish, butter, green leafy vegetables and some fishes.

Fluoride

9. 

Fluoride is vitally important for healthy teeth and for protecting the enamel against tooth decay. Tooth decay is a symptom of fluoride deficiency, and so brushing teeth daily is imperative in fighting against decay and plaque. Fluoride is an ingredient of tooth paste.

Sulphur

10. 

Sulphur is essential for the formation of protein in the body, as well as removing toxins from the blood. It is found in meat, poultry, shellfish, legumes, pulses and beans. It can delay the onset of diseases relating to old age.

MINERAL CONTENT OF EGGS , CEREALS AND CEREAL PRODUCTS, FRUITS AND VEGETABLES

Food products	**Na**	**K**	**Ca**	**Fe**	**P**
Eggs					
Chicken egg yolk	51	138	140	7.2	590
Chicken egg white	170	154	11	0.2	21
Cereals & cereal products					
Wheat, whole kernel	7.8	181	33	3.3	341
Wheat germ	5	993	49	8.5	1100
Corn flakes	915	120	13	2.0	59
Corn White	6	294	8	1.5	213
Rice, unpolished	10	238	16	3.2	282
Fruits					
Apple	1.2	122	5.8	0.25	12
Orange	1.4	165	42	0.19	23
Strawberry	1.4	161	21	0.64	29
Grapefruit	1.1	148	24	0.17	17
Plum	1.7	177	8.3	0.26	18
Vegetables					
Peas, green	2	274	24	1.7	113
Mushrooms	8	390	11	1.26	123
Potatoes	3.2	418	6.4	0.43	50
Carrots	60	321	37	0.39	35
Tomatoes	3.3	242	9.4	0.3	22

NUTRITIONAL AND FUNCTIONAL ROLE OF MINERALS AND MINERAL SALTS IN FOODS

Mineral	Food sources	Function
Aluminum	Part of ant acids & leavening agents	Essential nutrient, Acts as leavening agent & Texture modifier
Bromine	Brominated flour	Improves baking quality of wheat flour.
Calcium	Dairy products, Green leafy vegetables	Deficiency leads to osteoporosis in later life. Texture modifier.
Copper	Meat, seafoods, nuts	Catalyst in lipid peroxidation, ascorbic acid oxidation.
Iodine	Iodized salt, seafood	Deficiency causes goiter. Improves baking quality of wheat flour.
Iron	Cereals, legumes, meat	Deficiency leads to anemia. Catalyze lipid peroxidation in foods.
Magnesium	Cereals, green leafy vegetables	Removal of Mg from chlorophyll changes color from green to brownish
Manganese	Grains, fruits, vegetables	Cofactor in enzymes like pyruvate carboxylase, superoxide dismutase.
Nickel	Plant foods	Widely used catalyst for hydrogenation of vegetable oils.
Phosphates	Animal products	Acidulent in soft drinks. Acts as a leavening acid. Helps in retention of moisture in meats. Phosphates are used for the emulsification of processed cheeses and meats.
Potassium	Fruits and Vegetables	KCl may be used as a salt substitute.
Selenium	Seafood, cereals	Cofactor of Glutathione peroxidase.
Sodium	NaCl, MSG, milk	Used as flavour modifier. Used as a preservative. Many sodium salts are used as leaving agents.
Sulfur	Widely available	Present in methionine and cystine - essential amino acids. Sulfur dioxide and sulfites inhibit both enzymatic and nonenzymatic browning. Prevents, controls microbial growth.
Zinc	Meats, cereals	ZnO is used in the lining of cans for proteinaceous foods to lessen formation of black FeS during heating. Zn can be added to green beans to help stabilize the color during canning.

LESSON – 15

SUMMARY OF MINERALS

Mineral	Functions	Sources
Calcium	Maintains strong bones and healthy teeth. Helps the body to metabolize iron. Helps in regular heartbeat.	Milk, cheese, yoghurt, soya beans, sardines, dried beans, groundnuts and sunflower seeds.
Chlorine	Helps keep the body supple.	Table salt
Copper	Keeps up your energy by aiding iron absorption.	Dried beans and peas, whole wheat, prunes, calf and beef liver, most sea food.
Fluorine	Strengthens bones	Fluoride drinking water, sea food.
Iron	Promotes resistance to disease, prevents fatigue.	Red meat, liver and other glandular organs, egg yolk, nuts and dried fruits like dates, figs, etc .and leafy vegetables like spinach etc.
Magnesium	Promotes a healthy cardio-vascular system.	Figs, grape fruit, corn, almonds, nuts, apples, dark green leafy vegetables.
Manganese	Helps prevent fatigue. Aids in muscle reflexes.	Leafy vegetables, peas, beetroot, egg yolk, whole grain cereals and nuts.
Phosphorous	Helps the body to repair itself.	Fish, poultry, whole grains, egg, nuts and oil seeds.
Potassium	Assists in reducing blood pressure.	Oranges, lemons, grape fruit, green leafy vegetables, bananas, potatoes and sunflower seeds.
Selenium	Helps the tissues to retain its elasticity.	Wheat germ, bran, tuna fish, onions, tomatoes, broccoli.
Sodium	Helps the body muscles to function.	Kitchen salt, shellfish, carrot and green leafy vegetables.
Zinc	Governs the contractility of muscles.	Brewer's yeast, pumpkin seeds, eggs, lamb meat, soya beans, cereals, pulses, fish.

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LESSON-16
PIGMENTS & COLOURS

- Quality of food is generally based on colour, flavour, texture and nutritive value.
- Colour is one of the most important quality attributes of a food.
- The colour of a food is due to natural pigments present, except in cases where colourants have been added.
- Therefore an understanding of such pigment systems is essential.

Plant pigments

E.g. chlorophyll, anthocyanin, betanin, flavonoids, carotenoids etc.

Color

- To denote the human eye's perception of colored materials
- It is a part of the electromagnetic spectrum visible to the human eye and generally regarded as lying between 380 - 730 nm i.e. red, blue, or green.
- Together with flavor and texture, color plays an important role in food acceptability.
- Color is mainly a matter of transmission of light for clear liquid foods, such as oils and beverages.
- Color acceptability- economic worth, i.e. in many raw food materials

Colorant

A general term referring to any chemical compound (synthetically made) that impart (communicate) colori.e. dye & lake

Dye

Colorants used in textile industry, has no place in food usage.

Lake

A food colorant is synthetically made, absorbed on the surface of an inert carrier (i.e. alumina) and added to processed foods. Referred to as certified colors

Pigments present in vegetables and fruits include the water insoluble plastid pigments , the chlorophyll and carotenoids the cell-sap soluble pigments- the anthocyanins, flavones , flavonols, and similar substances.

These pigments may change in colour as a result of a change in physical state or of chemical reaction with metals,, acids, alkalis, oxygen ,etc.

The chief pigments of vegetables and fruits can be classified as water insoluble and water soluble.

- Water-Insoluble Pigments
- Water-Soluble pigments

Water-Insoluble Pigments

Chlorophyll:

The green pigments of leaves and stem are usually held close to the cell wall in small bodies called chloroplasts along with some carotenes and xanthophylls. Chlorophyll-a is intense blue green in colour and chlorophyll-b is dull yellow green in colour. Chlorophylls are mostly insoluble in water and dominant in unripe fruits. This pigment is present in green leafy vegetables, capsicum, beans, peas and chillies. Guava, gooseberry, country apple.

- Structure of chlorophyll consists of a porphyrin nucleus chelating a magnesium atom and a phytol tail.
- Porphyrin nucleus is made up of four pyrrole rings (tetrapyrrole). Pyrroles are cyclic compounds.
- Pyrrole rings are connected through methylene bridges.
- Phytol tail is a 20 carbon alcohol with an isoprenoid structure.

Deterioration of chlorophylls

- Addition of CuCl2 can prevent the degradation of chlorophyll in green pepper. Rapid chelating ability of the Copper complex (Copper phyllocyanate) and its high heat and acid stability prevents chlorophyll degradation.
- Vegetables turn olive green after 10 min cooking in boiling water. Acids are naturally present in all vegetables. Chlorophyll, which is protected by walls, are damaged during cooking allowing acidic compounds to come into contact with chlorophyll, which changes the colour.
- Longer a vegetable is cooked, more chlorophyll molecules will be altered and most of the green colour will be lost. Cooking green vegetables for 5-7 min. will protect chlorophyll from acidic damage.

Carotenoids:

In greens though carotenoids are present the colour is masked by the chlorophyll. In plants, carotenoids are present as α- carotene, β- carotene, ϒ- carotene, xanthophylls and cryptoxanthin. β- Carotene is valuable in the synthesis of vitamin A. Carotenoids : Mango, papaya, orange, watermelon (lycopene), musk melon (β- carotene), jackfruit, peaches, (violaxanthin) tomatoes, grape pink (lycopene, b- carotene) pine apple (violaxanthin b-carotene).

Lipid soluble pigments responsible for red, yellow, orange colours of plant and animal products. Found in carrots, tomatoes, yellow/ orange-coloured fruits, green leafy vegetables, red palm oil, butter, egg- yolk, algae etc. E.g.

- β-carotene
- Violaxanthin
- Neoxanthin
- Lutein
- Zeaxanthin-
- Lycopene
- Capsanthin
- Fucoxanthin
- Astaxanthin

Water-Soluble pigments

- These pigments are not membrane-bound molecules but are dissolved in the cell sap of epidermal cells of these parts.
- Flavonoids are classified into anthocyanins and anthoxanthins.
- Anthocyanins are highly water-soluble pigments that range in colour from red to purple.
- The anthoxanthins are colourless or white.

- Anthocyanins: Cherries, red apples, various berries blue and red grapes, pomegranates, and currants archive their colour appeal because of predominance of anthocyanins.
- The red colour in the skin of radishes and sweet potatoes and the leaves of red cabbage is due to anthocyanins too. Anthocyanin pigment in purple brinjal is water insoluble. Grapes, blueberries, plums, cherries.

Anthocyanins

Common in plant kingdom:

Several fruits, vegetables and flowers have themE.g. grapes, strawberries, apples, roses

Water-soluble pigments located in cell sap. Intensely colored – red, orange, blue, purple

Structure:

All anthocyanins are derived from flavylium cation. Twenty anthocyanins are known, but about six are important in foods.e.g. pelargonidin, cyanidin, delphinidin, pheonidin, petunidin and malvidin

Anthoxanthins

Anthoxanthins: Guava, apple, gooseberry, pears, custard apple, banana

Effect of pH

- The colour of the vegetable will be whiter if little acid such as lime juice or vinegar is added during cooking.
- If the water in which cauliflower is cooked is slightly alkaline, it will have a distinctly yellow colour to it. They turn yellow or orange in the presence of alkali.

Effect of metal

- They cause the cooking water to turn a bit yellow, when they are cooked in aluminium pans because the flavones scavenge aluminium and form a flavones aluminium chelate. Such reactions also take place in cast iron pans.
- Pears and white potatoes sometimes develop a pinkish colour in their cut surfaces when they stand for a while after being peeled or sliced. Apparently this colour change is due to conversion of the pro-anthocyanin to the pigmented and closely-related compound cyanidin.
- **Betanins**
  Group of compounds similar to anthocyanins in visual appearance.
- Found in beet, cactus fruits, amaranthus and flowers such as bougainvilla.
- About 70 betanins are known. Betanins are of two colours.
- Betaxanthin – yellow colour Betacyanin – red colour
- Betanins are subjected to thermal degradation but sufficient pigment is available even after canning.
- Isolated beet pigment is a potential food colourant.

Flavones: Good sources of flavones are celery, parsley, various herbs and hot peppers. Flavones are associated with overall antioxidant benefits

Flavonones: Flavonones are found abundantly in citrus fruits. They are associated with cardiovascular health, relaxation and overall antioxidant and anti-inflammatory activity.

Flavonols: They are found in onions, leeks, Brussels sprouts, kale, broccoli, tea, berries, beans and apples. Quercetin is an antihistamine associated with helping to relieve hay fever and hives. It is also known for its anti-inflammatory benefits.

Flavanols: There are three primary types of flavanols: monomers (more widely known as catechins), dimers and polymers. Flavanols are found in teas, cocoa, grapes, apples, berries, and red wine. Catechins are especially common in green and white teas, while dimers, which are associated with lowering cholesterol, are found in black tea.

Tannins

- Form yellow to brown colour.
- Tannins are a complex mixture of gallic acid, ellagic acid and glucose
- Different forms of tannins available. E.g.
- Tannic acid – 9 mol. gallic acid and 1 mol. glucose
- Condensed tannins – Dimers of catechin
- Hydrolyzable tannins – Polymers of gallic acid
- and ellagic acid

Flavour compounds

- The flavor of fruits and vegetables are extremely important to their acceptance in the diet.

- Sweetness may result from the presence of glucose, galactose, fructose, ribose, arabinose and xylose.

- All fruits and vegetables naturally contain a small amount of salt, which is detected in the overall taste impressions contributing to flavor.

- The natural flavor of vegetables are due to mixtures of aldehydes, alcohol, ketones, organic acids and sulphur compounds. Some fruits and vegetables have an astringent taste attributed to phenolic compounds or tannins.
- Tannins (or tannoids) are a class of astringent, polyphenolic biomolecules that bind to and precipitate proteins and various other organic compounds including amino acids and alkaloids.
- Two types of vegetable have strong flavours resulting from the presence of various sulphur containing compounds. Allyl sulphide found in onions, garlic and leeks. Brussle sprouts, broccoli, cabbage, turnips, cauliflower, kale and mustard are members of the family cruciferae, which also contain prominent volatile sulphur compounds

Flavour components of sulphur containing vegetables

Vegetables	Precursor	Reaction with treatment	Final volatile compound
Garlic	Alliin s-2-Propenyl (allyl) cysteine sulphoxide	Cutting/ Crushing results in allicin formation This undergoes nonenzymatic decomposition to disulphide and thiosulphinate	Disulphide further decomposes to a complex mixture of mono-sulphide and tri-sulphide – characteristic flavor
Onion	S-1-Propenyle cysteine sulphoxide	Cutting/ Crushing results in formation of sulphenic acids which is unstable and undergoes rearrangement	Thiopropanal-S-oxide-lfactor
Brassica family- Cabbage, cauliflower	S-methyl-cysteine sulphoxide and thioglucosidesn amino acid	Cooking	Dimethyl sulphides and isothiocyanates- give off-flavour

Sensory attributes
Appearance

The external characteristics of food products contribute to the overall appearance of a product. Jam with dry surface is not acceptable whereas a jelly with a glossy surface is rated high. Interior appearance can also be evaluated by looking at the internal colour, apparent abnormalities on the inner portions of the product etc. For example lumps in a sweet burfi or a jam which are not desirable can be judged by the eye.
The freshness of a fruit can be ascertained by observing the freshness of skin or peel. Spoiled bread can be identified by observing fungal growth on the surface Infestation with insects can be found out in brinjal by the appear-ance of black spots on it. Completeness of cooking can be judged by appear-ance in products like meat and rice.
Colour

Colour of a food can be considered as a good indicator of the quality in addition to giving pleasure. Ripeness of fruits like banana, tomato, mango, guava, papaya and plum can be assessed by the colour. The colour of the biscuit is used for its doneness. The strength of coffee and tea is judged in part by the colour of the beverages. The colour of roast chicken is used as an index to doneness. Toast, dosa, and chapathi which are too brown are likely to be rejected in anticipation of scorched bitter taste.

Flavour-Flavor is not a single entity, but it is comprised of odor and taste.
Odour:

- The sensation that results when olfactory receptors in the nose are stimulated by particular chemicals in gaseous form.
- An odour is caused by one or more volatilized chemical compounds, generally at a very low concentration, that humans perceive by the sense of olfaction.
- The odour of food contributes greatly to the pleasure of eating. A substance which produces odour must be volatile and the molecules of the substance must come in contact with receptors in the epithelium of the olfactory organ. Human olfactory sense has the capacity to distinguish about 16 million odours.
- Aroma is able to penetrate even beyond the visual range when strong chemical compounds are present in a food; an example is cut mango fruit and pulp.
- In mango fruit, more than 285 different aroma volatile compounds have been reported which include 7 acids, 55 alcohols, 31 aldehydes, 26 ketones, 14 lactones, 74 esters, 69 hydrocarbons, and 9 other compounds.
  The volatility of aromas is related to the temperature of the food.
- High temperatures tend to volatilise aromatic compounds, making them quite ap-parent for judging; cool or cold temperatures inhibit volatilisation.

Taste

- Food is valued greatly by its taste. In tasting a food the taste buds plays a major role they perceive the taste and register subsequently foods are categorised as sweet, salt, sour or bitter.
- Taste buds contain the receptors for taste.
- The papillae are involved in detecting the five (known) elements of taste perception: salty, sour, bitter, sweet, and savory (or umami

- The upper surface of the tongue, showing kinds of papillae and areas of taste.
- Taste buds near the tip of the tongue are more sensitive to sweet and salt. Those on the sides to sour and those near the back to bitter
- For example the sour sensation is associated with hydrogen ions supplied by acids like vinegar and by those found in fruits and vegetables.
- Saltiness- is a taste produced by the presence of sodium chloride (and to a lesser degree other salts).
- Sweetness is produced by the presence of sugars, some proteins and a few other substances. Sweetness is often connected to aldehydes and ketones which contain carbonyl group.

Bitterness is the taste which detects bases. Many people find bitter tastes to be unpleasant; many alkaloids taste bitter.

Savouriness(umami) is the name for the taste sensation produced by the free glutamates commonly found in fermented and aged foods. In English, it is sometimes described as "meaty" or "savoury". In the Japanese, the term umami is used for this taste sensation, whose characters literally mean "delicious flavour." Umami is now the commonly used term by taste scientists.

The glutamate taste sensation is most intense in combination with sodium. This is one reason why tomatoes exhibit a stronger taste after adding salt. Sauces with savoury and salty tastes are very popular for cooking, such as tomato sauces and ketchup for Western cuisines and soy sauce for East Asian and Southeast Asian cuisines

Astringency is dry puckery sensation believed to be due to precipitation of the proteins in the saliva and in the mucous membrane lining of the mouth which deprives them of their lubricating character. Unripe fruits-like cashew fruit, wood apple, blueberry and gooseberry are astringent..

LESSON-17
FOOD FLAVOURS

Flavors

Flavor is the sensation produced by a material taken in the mouth, perceived principally by the senses of taste and smell, and also by the general pain, tactile and tmperature receptors in the mouth. Flavor denotes the sum of the characteristics of the material which produces that sensation. Flavor is one of the three main sensory properties which help in deciding slection, acceptance and ingestion of food (the other two being appearance which includes colour, size shape, etc and kinesthetics which includes texture and consistency).

Flavor is composed of taste and odor. Other qualities like texture or temperature contribute to overall sensation of flavor. The main taetes are Salty (sodium chloride), Sweetness (sugar), Sourness (all acids like citric, tartaric etc), Bitterness (quinine), Umami (glutamic acid). The important odors are Camphoraceous (camphor), Pungent (formic acid), Etheral (chloroform), Floral (terpineol), Pepperminty (menthone), Musky (Androsan-3oc-ol), Putrid (skatole).

Flavor Compounds

Volatile compounds in food like aliphatic esters, aldehydes or ketones are responsible for aroma of foods. The important groups of flavoring compounds are as follows:

Flavonoids

They are responsible for flavor of fruits like orange, lemon. The peel of these fruits contain flavanone glycosides like Hesperidin (tasteless) and naringenin (bitter).

Terpenoids

They are omnipresent in plant foods. They contribute to flavor of citrus fruits and are major components of citrus oils. The major constituent of the essential oils is Limonene (about 90%).

Sulphur Compounds

Some volatile sulphur-containing compounds possess distinctive odours which contribute to aroma of many foods, e.g. the aroma of onion, garlic, cabbage, cauliflower, broccoli, etc. The compounds belong to class thioglucosides, isothiocyanates etc.

Other volatile flavor compounds

Foods can be classified into four groups in terms of volatile flavour. They are:

(1) Foods whose aroma is due to a single compound only. E.g., banana (isopentyl acetate), lemon (citral), almonds (benzaldehyde), etc.

(2) Foods whose aroma is due to mixture of small number of compounds, one of which is rhe major component. E.g., the major flavour imparting component of apple is 2-methyl butyrate and it contains four other components.

(3) Foods whose aroma can be reproduced with the help of a large number of compounds e.g., pinepple, walnut etc.

(4) Foods whose aroma cannot be reproduced by complex mixture of compounds e.g., strawberries, chocolate, etc.

The volatile compounds can be classified into following groups:

Carbonyl compounds: Acetaldehyde (butter), hexanal (apples), benzaldehyde (almonds, cherries), geranial (lemon), 2-3butanedione (butter, celery), etc

Acids: Acetic acid (vinegar), 2-methylbutyric acid (cranberries), etc

Esters: pentyl valerate (apple), methyl salicylate (grapes), pentyl acetate (banana), octyl acetate (orange), ethyl butyrate (strawberry), butyl acetate (strawberry), etc

Hydroxyl compounds: cis-3-hexen-1-ol (tomato, raspberry), 1-octen-3-ol (mushroom), phenol (some cheeses), eugenol (cloves), etc.

Types of flavors

The flavours can be broadly classified into three types

Developed flavor

Flavor compounds are formed during food processing and may originate from fractionation (manufacture of perfumes) and decomposition and other reactions of food components.

Processed flavor

Heating changes the flavor of many compounds, e.g., coffee, beans, peanuts, etc.

Added flavor

These are added to foods and are of two types

Essential oils or oleoresins or other extracts of aromatic plants, e.g., peppermint oil

Synthetic substances that may or may not occur in nature, e.g., benzaldehyde (almond), acetylmethylcarbinol (butter), citral (orange), eugenol (clove) limenone (lemon), vanillin (vanilla), etc.

Flavor Enhancement

Monosodium glutamate

It is prepared from wheat gluten, beet sugar waste and soy protein. It is also used in the form of protein hydrolysate derived from proteins. Wheat gluten, casein and soy flour are good sources of glutamic acid and are used to prepare protein hydrolysates.

The flavour of glutamate is unique and has no resemblance to flavour of other compounds. Glutamate causes a tingling feeling and persistency of tatse sensation. It provides a feeling of satisfaction. Presence of salt is required to produce glutamate effect. Monosodium glutamate improves the flavour of many food products and is widely used in processed foods like meat and poultry products, soups, vegetables and seafood.

Maltol

Maltol has the ability to enhance sweetness produced by sugars. Maltol is formed during roasting of malt, coffee, cacao and grains. It is also formed in the crust of bread during baking process and in dairy products that have been heated as a product of decomposition of casein-lactose system. Maltol has anti-oxidant properties. It increases storage life of coffee and roasted cereal products. Maltol is used as a flavour enhancer in chocolate, candies, ice cream, baked products, instant coffee and tea, liqueurs and flavourings.

LESSON-18

INTRODUCTION TO FOOD MICROBIOLOGY: BACTERIA

Introduction

Food science is a discipline concerned with all aspects of food - beginning after harvesting, and ending with consumption by the consumer. It is considered one of the agricultural sciences, and it is a field which is entirely distinct from the field of nutrition. The field of food microbiology is a very broad one, encompassing the study of microorganisms which have both beneficial and deleterious effects on the quality and safety of raw and processed foods. It is important to understand the relationships among the various microorganisms making up the microflora of a food. Infact food microbiologists are concerned with the practical implications of the microflora of the food and the food microorganisms that can cause spoilage of food and disease in humans. The primary tool of microbiologists is the ability to identify and quantitate food-borne microorganisms. However, the inherent inaccuracies in enumeration processes, and the natural variation found in all bacterial populations complicate the microbiologist’s job. Moreover, they may be important from the aesthetic point of view. Of course, some useful bacteria may be important because they change the functional properties of food stuffs resulting in new tastes, odors or textures. Microorganisms in food include bacteria, molds, yeasts, algae, viruses, parasitic worms and protozoa. These organisms differ in size and shape and in their biochemical and cultural characteristics.

The microorganisms described below are among the most important genera and species normally found in food products. Each microorganism has its own particular nutritional and environmental requirements.

Bacteria

Acinetobacter

Acinetobacter is a genus of Gram-negative bacteria belonging to the Gammaproteobacteria . Acinetobacter species are non-motile and oxidase-negative, and occur in pairs as observed under magnification. Young cultures show rod shaped morphology. They are strict aerobes that do not reduce nitrates. They are important soil and water organisms and are also found on many foods especially refrigerated fresh products. A. baumannii is a frequent cause of nosocomial pneumonia, especially of late onset ventilator associated pneumonia. It can cause various other infections including skin and wound infections, bacteremia, and meningitis

Bacillus cereus

B. cereus is a thick long rod shaped Gram positive, catalase positive aerobic spore former and the organism is important in food borne illness. It is a normal inhabitant of soil and is isolated from a variety of foods. It is quite often a cause of diarrheal illness due to the consumption of desserts, meat, dishes, dairy products, rice, pasta etc that are cooked and kept at room temperature as it is thermoduric. Some of the B. cereus strains are psychrotrophic as they grow at refrigeration temperature.

B. cereus is spread from soil and grass to cows udders and into the raw milk. It is also capable of establishing in cans. It is also capable of producing proteolytic and amyloltic enzymes and also phoslipase C (lecithinase). The production of these enzymes by these organisms can lead to the spoilage of foods. The diarrheal illness is caused by an enterotoxin produced during the vegetative growth of B. cereus in small intestine. The bacterium has a maximum growth temperature around 48°C to 50°C and pH range 4.9 to 9.3. Like other spores of mesophilic Bacillus species, spores of B. cereus are also resistant to heat and survive pasteurization temperature.

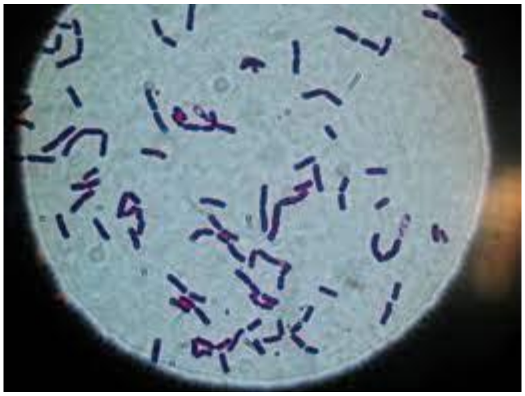


Fig. Bacillus cereus

Bacillus subtilis

Bacillus subtilis , known also as the hay bacillus or grass bacillus , is a Gram-positive, catalase-positive bacterium commonly found in soil. A member of the genus Bacillus, B. subtilis is thin short rod-shaped, and has the ability to form a tough, protective endospore, allowing the organism to tolerate extreme environmental conditions. B. subtilis produces the proteolytic enzyme subtilisin. B. subtilis spores can survive the extreme heat during cooking. B. subtilis is responsible for causing ropiness a sticky, stringy consistency caused by bacterial production of long-chain polysaccharides in spoiled bread dough. A strain of B. subtilis formerly known as Bacillus natto is used in the commercial production of the Japanese food natto, as well as the similar Korean food cheonggukjang. It is used to produce amylase and also used to produce hyaluronic acid, which is useful in the joint-care sector in healthcare.

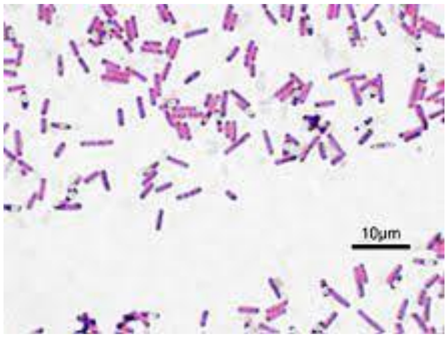


Fig. Bacillus subtilis

Carnobacterium

Carnobacterium is a genus of Gram-positive bacteria within the family Leuconostocaceae. C. divergens and C. maltaromaticum are found in the wild and in food products and can grow anaerobically. These species are not known to be pathogenic in humans but may cause disease in fish. The genus Carnobacterium contains nine species, but only C. divergens and C. maltaromaticum are frequently isolated from natural environments and foods. They are tolerant to freezing/thawing and high pressure and able to grow at low temperatures, anaerobically. They metabolize arginine and various carbohydrates, including chitin, and this may improve their survival in the environment. Carnobacterium divergens and C. maltaromaticum have been extensively studied as protective cultures in order to inhibit growth of Listeria monocytogenes in fish and meat products. Several carnobacterial bacteriocins have been identified and described. Carnobacteria can spoil chilled foods, but spoilage activity shows intraspecies and interspecies variation. Their production of tyramine in foods is critical for susceptible individuals, but carnobacteria are not otherwise human pathogens.

Corynebacterium

Corynebacterium is a genus of Gram-positive rod-shaped bacteria. They are widely distributed in nature and are mostly innocuous. Some are useful in industrial settings such as C. glutamicum. Others can cause human disease. C. diphtheriae, for example, is the pathogen responsible for diphtheria. Some species are known for their pathogenic effects in humans and other animals. Perhaps the most notable one is C. diphtheriae, which acquires the capacity to produce diphtheria toxin only after interacting with a bacteriophage. Diphtheria toxin is a single, 60,000 molecular weight protein composed of two peptide chains, fragment A and fragment B, held together by a disulfide bond.

Clostridium perfringens

C. perfringens is a Gram-positive encapsulated anaerobic non-motile bacterium commonly found on meat and meat products. It has the ability to cause food borne disease. It is a toxin producing organism-produces C. perfringens enterotoxin and β -toxin that are active on the human GI tract. It multiplies very rapidly in food (doubling time < 10 min). Spores are resistant to radiation, desiccation and heat and thus survive in incompletely or inadequately cooked foods.

However, it tolerates moderate exposure to air. Vegetative cells of C. perfringens are also somewhat heat tolerant as they have relatively high growth temperature (43°C -45 °C) and can often grow at 50°C. They are not tolerant to refrigeration and freezing. No growth occurs at 6 °C . C. perfringens is present in soil and the other natural environment.

Fig.Clostridium spp.

Clostridium botulinum

C. botulinum produces the most potent toxin known. It is a Gram-positive anaerobic rod shaped bacterium. Oval endospores are formed in stationary phase cultures. There are seven types of C. botulinum (A to G) based on the serological specificity of the neurotoxin produced. Botulism is a rare but very serious disease. The ingestion of neurotoxin produced by the organism in foods can lead to death. However, the toxin (a protein) is easily inactivated by heat. The organism can grow at temperature ranging from 10-48 °C with optimum growth temperature at 37°C. Spores are highly heat resistant. The outgrowth of spores is inhibited at pH < 4.6, NaCl> 10% or water activity< 0.94. Botulinum spores are probably the most radiation resistant spores of public health concern. Contamination of foods is through soil and sediments where they are commonly present. The organism grows under obligate anaerobic conditions and produces toxin in under processed (improper canning) low acid foods at ambient temperature.

Fig. Clostridium botulinum

Campylobacter

Campylobacter are Gram negative nonspore forming rods. Campyloleacter jejuni is an important food borne pathogen. It is one of the many species within the genus Campylobacter. Campylobacter species C. jejuni and C. coli cause diarrhea in humans. The organism is heat sensitive (destroyed by milk pasteurization temperature). It is also sensitive to freezing. The organism belongs to the family Campylobactereaceae. The organisms are curved, S-shaped, or spiral rods that may form spherical or coccoids forms in old cultures or cultures exposed to air for prolonged periods. Most of the species are microaerophilic. It is oxidase and catalase positive and does not grow in the presence of 3.5% NaCl or at 25 °C or below. The incidence reported for gastro enteritis by this organism are as high as in case of Salmonella.

The organism is commonly present in raw milk, poultry products, fresh meats, pork sausages and ground beef. The infective dose of C.jejuni may be <1,000 organisms.

Fig. Campylobacter

Erwinia

Erwinia is a genus of the family Enterobacteriaceae bacteria containing mostly plant pathogenic species. The organisms was named after the first phytobacteriologist, Erwin Smith. It is a Gram negative bacterium related to E. coli, Shigella, Salmonella and Yersinia. It is primarily a rod-shaped bacterium. A well-known member of this genus is the species E. amylovora, which causes fire blight on apple, pear and other Rosaceous crops. Erwinia carotovora (also known as Pectobacterium carotovorum) is another species, which causes diseases in many plants. These species produce pectolytic enzymes that hydrolyze pectin between individual plant cells. . Decay caused by E. carotovora is often referred to as bacterial soft rot (BSR). Most plants or plant parts can resist invasion by the bacteria, unless some type of wound is present. High humidity and temperatures around 30°C favor development of decay.

Enterococcus (E. faecium, E. faecalis)

Enterococcus is a genus of lactic acid bacteria. Enterococci are Gram positive cocci that often occur in pairs (diplococci) or short chains and are difficult to distinguish from streptococci on physical characters mentioned above. The two species are commensal organisms in the intestine of humans.

The Enterococci are facultative anaerobic organisms non spore forming that grows optimally at 35°C . However, they tolerate wide range of environmental conditions (10-45°C) pH (4.5 to 10.5) quite high NaCl concentration (.6.5%) and can survive heating at 60°C for 30 min.

Escherichia coli

E. coli strains are associated with food borne gastroenteritis. These are Gram-negative asprogeneous rods that ferment lactose and produce dark colonies with a metallic sheen on Endo agar. The organism grows well on a large number of media and in many foods. They grow over a wide range of temperature (4 to 46 °C) and pH (4.4 to 9.0).

However, they grow very slowly in foods held at refrigerator temp. (5 °C). They belong to the family Enterobacteriaceae. The organism is also an indicator of fecal pollution. The organism is also capable of producing acid and gas and off-flavours in foods. E. coli strains involved in foodborne-illness can be placed into five groups: enteropathogenic (EPEC), enterotoxigenic (ETEC), enteroinvasive (EIEC), enterohemorrhagic (EHEC) and facultatively enteropathogenic (FEEC).

The organism also grows in the presence of bile salts. The primary habitat of E.coli is the intestinal tract of most warm blooded animals. E.coli 0157: H7 strains are unusually tolerant of acidic environments.

Lactococcus

L.lactis subsp. lactis

L.lactis subsp. cremoris

L.lactis subsp.lactis biovar diaectylactis

Lactococcus is a genus of lactic acid bacteria that were formerly included in the genus Streptococcus Group N (Group N Streptococci). They are known as homofermentors meaning that they produce a single product of glucose fermentation. They are Gram-positive, catalase negative, non-motile coccus that are found singly, in pairs or in chains. Some of the strains of lactococci are known to grow at or below 7 °C.

Lactococci are intimately associated with dairy products. These organisms are commonly used in the dairy industry in the manufacture of fermented dairy products like cheeses. They can be used in single strain starter cultures or in mixed strain cultures with other lactic acid bacteria such as Lactobacillus and Streptococcus. Their main purpose in dairy production is the rapid acidification of milk. This causes drop in the pH of fermented product which prevents the growth of spoilage and pathogenic bacteria. These bacteria also play a role in the flavor of the final product. Dairy lactococci have also been exploited for several industrial fermentations in the biotechnology industry. They are easily grown at industrial scale up on cheap whey based media.

Lactococcus lactis subsp. lactis includes species formerly designated as S. lactis subsp. lactis. L. lactis subsp. cremoris is distinguished from L. Lactis subsp. lactis by the inability to (i) grow at 40 °C (ii) grow in 4% NaCl (iii) hydrolyse arginine and (iv) ferment ribose.

L. acidophilus, L. casei, L. lactis, L. fermentum)

The organisms belonging to this important genus are rods usually long and slender and in some of the species form chains. They are aerotolerant/microaerophilic but some ferment sugars chiefly to lactic acids if they are homofermentative. The hetero fermentative species, besides lactic acid, also produce small amount of acetic acid, carbon dioxide and trace amounts of volatile compounds such acetaldehyde and alcohol. The homofermentative species of Lactobacillus include L. bulgaricus, L. casei, L. helveticus, L. lactis, L. acidophilus and grow optimally at 37 °C. L. fermentum, L. brevis are the typical example of hetero fermentative Lactobacillus and grow well at higher temperatures.

Lactobacilli are of considerable importance in foods as they ferment sugar to lactic acid and other desirable flavouring compounds and are thus used in the production of fermented plant dairy and meat products. However, they are also implicated in the spoilage of wine and beer.

The organism normally occurs on plant surfaces silage, manure and dairy products. They are quite fastidious in their nutritional requirements as they are unable to synthesize certain vitamins they require and, therefore, media need to be supplemented with these vitamins for their growth.

Some of the strains are psychotrophic in nature and are thus involved in the spoilage of refrigerated meats. On the other hand thermoduric properties (resistance to pasteurization temperature) of some of the thermophilic strains of lactobacilli are quite useful in the manufacture of certain varieties of cheeses e.g. Swiss cheese. Some strains of lactobacilli also show probiotic attributes and are finding application in functional probiotic foods and in pharmaceutical preparations.

Leuconostoc

Leuconostoc is a genus of Gram-positive bacteria, placed within the family of Leuconostocaceae. They are generally ovoid cocci often forming chains. Leuconostoc spp. are intrinsically resistant to vancomycin and are catalase-negative (which distinguishes them from staphylococci). All species within this genus are heterofermentative and are able to produce dextran from sucrose. They are generally slime-forming. Blamed for causing the 'stink' when creating a sourdough starter, some species are also capable of causing human infection.

Leuconostoc spp. along with other lactic acid bacteria such as Pediococcus and Lactobacillus spp , is responsible for the fermentation of cabbage, to sauerkraut. In this process the sugars in fresh cabbage are transformed to lactic acid which give it a sour flavour and good keeping qualities.

Listeria monocytogenes

Listeria monocytogenes in foods has attracted worldwide attention due to the serious illness it causes in human beings. The Listeria are Gram positive non spore forming, nonacid-fast rods. The organism is catalase positive and produces lactic acid from glucose and other fermentable sugars. The organism grows well in brain heart infusion (BHI), trypticase soy, and tryptose broths. However, the medium should be fortified with B. vitamins and the amino acids. It is a mesophilic organism with optimal growth temperature 37°C but it can grow at refrigerator temperature also. Strains grows over the temperature range of 1°C to 45°C and pH range 4.1 to 9.6.

Listeria monocytogenes is widely distributed in nature and can be isolated from decaying vegetation, soil, animal feces, sewage, silage and water. The organism has been found in raw milk, pork, raw poultry, ground beef and vegetables. The HTST treatment of pasteurization is good enough to destroy the organism in milk.

The most significant virulence factor associated with L. monocytogenes is listeriolysin O. The virulent strains produce β-hemolysis on blood agar and acid from rhamnose.

L. monocytogenes grows well in moderate salt concentrations (6.5%).

L. monocytogenes is unique among foodborne pathogens while other pathogens excrete toxins or multiply in the blood stream, L. monocytogenes enters the host’s cells and grows inside the cell. In humans it crosses the intestinal barrier after entering by the oral route.

Ready to Eat (RTE) foods that are preserved by refrigeration pose a special challenge with regard to L. monocytogenes infection.

Pseudomonas fluorescens

Pseudomonas fluorescens is a common Gram-negative, rod-shaped, motile bacterium. The organism is psychrotrophic in nature and grows at refrigeration temperature (7°C). It has an extremely versatile metabolism, and can be found in the soil and in water. It is an obligate aerobe, but certain strains are capable of using nitrate instead of oxygen as a final electron acceptor during cellular respiration. Optimal temperature for growth of Pseudomonas fluorescens is 25-30 °C. It tests positive for the oxidase. Pseudomonas fluorescens is also a nonsaccharolytic organism. Heat-stable lipases and proteases are produced by Pseudomonas fluorescens and other similar pseudomonads. These enzymes cause milk to spoil, by causing bitterness, casein breakdown, and ropiness due to the production of slime and coagulation of proteins.

Pseudomans aeruginosa

It is a Gram-negative, aerobic, rod-shaped bacterium with unipolar motility. An opportunistic human pathogen, P. aeruginosa is also an opportunistic pathogen of plants. P. aeruginosa is the type species of the genus Pseudomonas (Migula). Gram-stained Pseudomonas aeruginosa bacteria (pink-red rods) secretes a variety of pigments, including pyocyanin (blue-green), pyoverdine (yellow-green and fluorescent), and pyorubin (red-brown). P. aeruginosa is often preliminarily identified by its fluroscence and grape-like or tortilla-like odor in vitro. Definitive clinical identification of P. aeruginosa often includes identifying the production of pyocyanin and fluorescein, as well as its ability to grow at 42°C. P. aeruginosa is capable of growth in diesel and jet fuel, where it is known as a hydrocarbon-using microorganism (or "HUM bug"), causing microbial corrosion. P. aeruginosa is considered by many as a facultative anaerobe

Salmonella (S. typhimurium, S. typhi, S.enteritidis)

Salmonella spp. have been reported to be a leading cause of foodborne illnesses in humans. Foodborne salmonellosis scores over all other foodborne bacterial illnesses in humans. Enteric fever is a serious human disease associated with typhoid and paratyphoid strains. SalmonellaEnterobacteriaceae. The optimum growth temperature is 37-45 °C. The organism can also grow at about 7°C in foods. I t ferments carbohydrates with its production of acid and gas. Salmonella are oxidase negative, catalase positive and grow on citrate as a sole carbon source and produce $H2S$. Some Salmonella strains can grow at higher temperatures (54 °C) while others exhibit psychrotrophic properties. The organism has the ability to grow at pH values ranging from 4.5 to 9.5, with an optimum pH growth at 6.5 to 7.5. spp. are facultatively anaerobic, small Gram-negative, non spore forming, rod-shaped (2-4 m m) bacteria belonging to the family

Milk, meat and poultry are principle vehicles of human foodborne salmonellosis. Ingestion of only a few salmonella cells can be infectious. Low levels of salmonellae in a finished food products may, therefore, be of serious public health consequence.

Streptococcus thermophilus

The only streptococcus species that is associated with food technology is S. thermophilus which is used in the manufacture of yoghurt (in co culture with L. bulgaricus and Dahi).

S. thermophilus is a Gram positive facultative anaerobe and belongs to the family Streptococcaceae. It is catalase negative organism that is non-motile, non-spore forming and homofermentative and occurs in pairs to long chains. The spherical to avoid cells are with a diameter in the range of 0.7 to 0.9 µm. The optimum temperature for the growth of this organism is between 39°C to 45°C, although most species in the genus are able to grow at temperature ranging from 45-60°C. They do not grow at temperature below 20°C, but they can survive at 65°C for 30 min. They ferment sugars with L (+) lactic acid as the major end product and produce around 0.6 to 0.8% lactic acid. They are able to grow in broth with 2.5% NaCl but fail to grow in 6.5% NaCl at pH 9.6 or in milk with 0.1% methylene blue (Bergey's Manual 1994). It is also classified as lactic acid bacteria (LAB). It is a very versatile organism. S. thermophilus has properties that make it one of the commercially most important lactic acid organism. S. thermophilus is used along with Lactobacillus spp., as a starter culture to manufacture several important fermented dairy foods including yoghurt and mozzarella cheese.
Though the natural habitat of S. thermophilus is yet to be established, most strains have been isolated from milk environments**.**

Shigella

Bacillary dysentery, or shigellosis, is caused by Shigella species. Shigella is a member of the family Enterobacteriaceae. The growth temperature varies from 10 to 48 °C. Shigella2S. Shigella does not usually survive well in low pH foods. Shigella is sensitive to ionizing radiations. species are non-motile, oxidase negative produce acid only from sugars; do not grow on citrate as sole carbon source, do not grow on KCN agar, and unlike Salmonellae do not produce H

Shigellosis is an important disease in developed and developing countries. Disease is caused by ingestion of contaminated foods, and in some instances it subsequently leads to rapid dissemination through contaminated feces from infected individuals. The infective dose may be as low as 100 cells. Contamination of foods usually does not occur at the processing plant but rather through an infected food handler. Humans are the natural reservoir of Shigella. The organism is spread through the fecal-oral route.

Vibrio

Vibrio cholerae and V. parahaemolyticus are the two important species of the genus Vibrio. Vibrio cholerae O1 causes cholera, one of the few food borne illnesses with epidemic and pandemic potential. Vibrio cholerae are Gram-negative straight or curved rods and belong to the family Vibrionaceae. Important distinctions within the species are made on the basis of productions of cholera enterotoxin (CT) and serogroup.

Vibrio cholerae is part of the normal free living bacterial flora in estuarine areas. Amongst the many different enrichment broths described for the isolation of vibrios alkaline peptone water is the most commonly used. Though V. parahaemolyticus can grow in the presence of 1-8% NaCl, the best growth occurs in the salt concentration 2 to 4%.

Yersinia

Yersinia enterocolitica and Yersinia pestis are the two important human pathogens while Y. enterocolitica causes food borne gastroenteritis, Y. pestis is an agent of human plague. Y. enterocolitica also known as newly emerging human pathogen is a heterogeneous species that is divisible into a large number of subgroups.

Y. enterocolitica is unusual because it can grow at temperatures below 4 °C. The generations time at the 28-30 °C (Optimum growth temperature) is almost 34 min. It also survives in frozen foods. It grows better in processed foods such as pasteurized milk, vacuum packed meat, boiled eggs, boiled fish, and cottage cheese.
Both the species can grow over a pH range of 4 to 10 (optimum pH is 7.6) and tolerate alkaline environment well. They can motile at a temperature < 30 °C. However, both these organisms are susceptible to pasteurization, ionizing and ultraviolet (UV) irradiation. The organism can also tolerate upto 5% NaCl.
Infections with Yersinia species are due to transmittance of the organism from animals to humans. The organism is frequently present in pork, lamb, poultry and dairy products.

LESSON-19
INTRODUCTION TO FOOD MICROBIOLOGY: YEAST, MOLD AND VIRUS

Food Borne Yeasts

Yeasts have been associated with foods since earliest times, both as beneficial agents and as major causes of spoilage and economic loss. Current losses to the food and dairy industry caused by yeast spoilage are estimated at several billion dollars. As new food ingredients and new food manufacturing technologies are introduced, novel food spoilage yeasts are emerging to present additional problems. To date over 70 biological species of yeasts have been described and thousands of different varieties have been shown to exist in all kinds of natural and artificial habitats.

Yeasts may be viewed as being unicellular fungi in contrast to the molds, which are multi-cellular. Yeasts can be differentiated from bacteria by their larger cell size and their oval, elongate, elliptical, or spherical cell shapes. Typical yeast cells range from 5 to 8 um in diameter, with some being even larger. Older yeast cultures tend to have smaller cells. Most of those of importance in foods divide by budding or fission.

Yeasts can grow in presence of various types of organic acids such as lactic, citric and tartaric acid etc and also over a wide range of acid pH and in up to 18% ethanol. Many grow in the presence of 55-60% sucrose. Many colours are produced by yeasts, ranging from creamy to pink to red. The asco- and arthrospores of some are quite heat resistant.

Candida

Members of the Candida genus form shining white colonies and cells contain no carotenoid pigments. Candida tropicalis is the most prevalent in foods in general Some members are involved in the fermentation of cocoa beans, as a component of kefir grains, and many other products, including beers, and fruit juices.

Debaromyces

Debaromyces is one of the most prevalent yeast genera in the dairy products. It can grow in 24% NaCl and at an aw as low as 0.65.

Rhodotorula

The genus Rhodotorula contains many psychrotrophic species that are found on fresh poultry, shrimp, fish and beef. Some grow on the surface of butter.

Saccharomyces

Saccharomyces are ascosporogenous yeasts that multiply by lateral budding and produce spherical spores in asci. They are diploid and do not ferment lactose. All bakers' brewers', wine and champagne yeasts are S. cerevisiae. They are found in Kefir grains and can be isolated from wide range of foods. S. cerevisiae rarely causes spoilage.

Food-Borne Molds

Molds are filamentous fungi that grow in the form of tangled mass that spreads rapidly and may cover several inches of area in a very short period. It is also referred to as mycelial growth. Mycelium is composed of branches of filaments referred to as hyphae. The molds of great importance in foods multiply by ascospores or conidia. The ascospores of some of the mold genera are notable for their extreme degrees of heat resistance.

Alternaria

Alternaria spp. form septate mycelia with conidiophores and large brown conidia are produced. They cause brown to black rots of fruits, apples, and figs. Some species produce mycotoxins.

Aspergillus

The Aspergillus spp. appear yellow to green to black on a large number of foods. Some species cause spoilage of oils. A. niger produces β-galactosidase, glucoamylase, invertase, lipase and pectinase. A. oryzae produces a -amylase. Two species A. flavus and A. parasiticus produce aflatoxins, and others produce ochratoxin A and sterigmatocystin.

Geotrichum

The yeast like fungi, Geotrichum are also referred to as dairy mold.

Mucor and Rhizopus

Mucor species that produce non-septate hyphae are prominent food spoilers. Similarly, Rhizopus spp. also produce non septate hyphae but give rise to stolons and rhizoids. R. stolonifer is by far the most common species in foods and is also referred to as “bread mold”.

Other important genera of molds related to spoilage of foods are Neurospora, Thamnidium, Trichothecium, Penicillium and Cladosporium etc.

Food Borne Viruses

Viruses are filterable, ultra microscopic particles and can be cultivated only on live tissues. Viruses consist of a core of nucleic acid (DNA or RNA) and a protein coat. It is commonly believed that some of the viruses are responsible for food borne diseases in humans, particularly some non bacterial gastroenteritis due to enteroviruses. Contaminated water and food are important carriers of hepatitis viruses. Foot and mouth disease (FMD) causing virus in cattle can be transmitted to human beings through foods. Similarly, viral diseases of poultry have also been source of ailments in humans.

LESSON-20

FACTORS AFFECTING GROWTH AND SURVIVAL OF MICROORGANISMS IN FOODS

Introduction

Food spoilage means the original nutritional value, texture, flavour, etc.,of the food are damaged, the food become harmful to people and unsuitable to eat. Food can deteriorate as a result of two main factors:

1)Growth of micro-organisms - usually from surface contamination - especially important in processed food

2) Action of enzymes - from within cells - part of normal life processes, (responsible for respiration, for instance). It is important to note that many plants - fresh vegetables and fruit - are still alive when bought and even when eaten raw, and meat from animals undergoes gradual chemical changes after slaughter.

A variety of intrinsic and extrinsic factors determine whether microbial growth will preserve or spoil foods, as shown in Table 3.3. Intrinsic or food related parameters are those parameters of plants and animal tissues which are inherent part of the tissue. e.g., pH, water activity (a W), oxidation-reduction potential (Eh), nutrient content, antimicrobial constituents and biological structures. Extrinsic or environmental parameters are properties of storage environments which affect both foods as well as microorganisms and include temperature of storage, relative humidity of storage environment, and concentration of gases in environment.

Intrinsic Parameters

Nutrient content

Like all other living beings, microorganisms need water, a source of carbon, an energy source, a source of nitrogen, minerals, vitamins and growth factors in order to grow and function normally. Since foods are rich source of these compounds, they can be used by microorganisms also. It is because of these reasons that various food products like malt extracts, peptone, tryptone, tomato juice, sugar and starch are incorporated in microbial media. The inability to utilize a major component of the food material will limit its growth and put it at a competitive disadvantage compared to those that can. In general, molds have the lowest requirement, followed by yeasts, Gram-negative bacteria, and Gram-positive bacteria. Many food microorganisms have the ability to utilize sugars, alcohols, and amino acids as sources of energy. Few others are able to utilize complex carbohydrates such as starches and cellulose as sources of energy. Some microorganisms can also use fats as the source of energy, but their number is quite less. The primary nitrogen sources utilized by heterotrophic microorganisms are amino acids. Also, other nitrogenous compounds which can serve this function are proteins, peptides and nucleotides. In general, simple compounds such as amino acids are utilized first by a majority of microorganisms.

Water activity (aW)

Water is often the major constituent in foods. Even relatively ‘dry’ foods like bread and cheese usually contain more than 35% water. The state of water in a food can be most usefully described in terms of water activity.

Water activity of a food is the ratio between the vapour pressure of the food, when in a completely undisturbed balance with the surrounding air, and the vapour pressure of pure water under identical conditions. Water activity, in practice, is measured as Equilibrium Relative Humidity (ERH) and is given by the formula:

Water Activity (aW) = ERH / 100

Water activity is an important property that can be used to predict food safety, stability and quality. The various applications of water activity includes maintaining the chemical stability of foods, minimizing non enzymatic browning reactions and spontaneous autocatalytic lipid oxidation reactions, prolonging the desired activity of enzymes and vitamins in foods, optimizing the physical properties of foods such as texture.

Water activity scale extends from 0 (bone dry) to 1.00 (pure water). But most foods have a water activity in the range of 0.2 for very dry foods to 0.99 for moist fresh foods. Based on regulations, if a food has a water activity value of 0.85 or below, it is generally considered as non-hazardous. This is because below a water activity of 0.91, most bacteria including the pathogens such as Clostridium botulinum cannot grow. But an exception is Staphylococcus aureus which can be inhibited by water activity value of 0.91 under anaerobic conditions but under aerobic conditions, it requires a minimum water activity value of 0.86. Most molds and yeasts can grow at a minimum water activity value of 0.80. Thus a dry food like bread is generally spoiled by molds and not bacteria. In general, the water activity requirement of microorganisms decreases in the following order: Bacteria > Yeast > Mold. Below 0.60, no microbiological growth is possible. Thus the dried foods like milk powder, cookies, biscuits etc are more shelf stable and safe as compared to moist or semi-moist foods.

Factors that affect water activity requirements of microorganisms include the following- kind of solute added, nutritive value of culture medium, temperature, oxygen supply, pH, inhibitors, etc.

Water acts as an essential solvent that is needed for most biochemical reactions by the microorganisms. Water activity of the foods can be reduced by several methods: by the addition of solutes or hydrophilic colloids, cooking, drying and dehydration: (e.g. egg powder, pasta), or by concentration (e.g. condensed milk) which restrict microbial growth so as to make the food microbiologically stable and safe.

A wide variety of foods are preserved by restricting their water activity. These include:
Dried or low moisture foods

These contain less than 25% moisture and have a final water activity between 0.0 and 0.60. e.g., Dried egg powder, milk powder, crackers, and cereals. These products are stored at room temperature without any secondary method of preservation. These are shelf stable and do not spoil as long as moisture content is kept low.

Intermediate moisture foods

These foods contain between 15% and 50% moisture content and have a water activity between 0.60 and 0.85. These foods normally require added protection by secondary methods such as pasteurization, pH control, refrigeration, preservatives, but they can also be stored at room temperature. These include dried fruits, cakes, pastries, fruit cake, jams, syrups and some fermented sausages. These products are usually spoiled by surface mold growth.

pH and buffering capacity

The pH, or hydrogen ion concentration, [H+], of natural environments varies from about 0.5 in the most acidic soils to about 10.5 in the most alkaline lakes. Since the pH is measured on a logarithmic scale, the [H+] of natural environments varies over a billion-fold and some microorganisms are living at the extremes, as well as every point between the extremes. The range of pH over which an organism grows is defined by three cardinal points: the minimum pH, below which the organism cannot grow, the maximum pH, above which the organism cannot grow, and the optimum pH, at which the organism grows the best. Microorganisms which grow at an optimum pH well below neutrality (7.0) are called acidophiles. Those which grow best at neutral pH are called neutrophiles and those that grow best under alkaline conditions are called alkalophiles. In general, bacteria grow faster in the pH range of 6.0- 8.0, yeasts 4.5-6.5 and filamentous fungi 3.5-6.8, with the exception of lactobacilli and acetic acid bacteria with optima between pH 5.0 and 6.0**.**

Redox potential (Eh)

Microorganisms display varying degrees of similarity to Oxidation-Reduction potential of their growth medium. The O/R potential is the measure of tendency of a revisable system to give or receive electrons. When an element or compound looses electrons, it is said to be oxidized, while a substrate that gains electrons becomes reduced. Thus a substance that readily gives up electrons is a good reducing agent, while one that readily gains electrons is a good oxidizing agent. When electrons are transferred from one compound to another, a potential difference is created between the two compounds and is expressed in as milk volts (mV). If a substance is more highly oxidized, the more positive will be its electrical potential and vice versa. The O/ R potential of a system is expressed as Eh. Aerobic microorganisms require positive Eh values for growth while anaerobic microorganisms require negative Eh values (reduced). The redox potential we measure in a food is the result of several factors: redox couples present, ratio of oxidant to reductant, pH, poising capacity, availability of oxygen and microbial activity.

Antimicrobial constituents and barriers

Some foods can resist the attack by microorganisms due to the presence of certain naturally occurring substances which possess antimicrobial activity such as essential oils in spices (eugenol in cloves and cinnamon, allicin in garlic, cinnamic aldehyde in cinnamon, thymol in sage); lactaferrin, lactoperoxidase and lysozyme in milk; and ovatransferrin, avidin, lysozyme and ovoflavoprotein in hen's egg albumin. Similarly, casein as well as free fatty acids found in milk also exhibit antimicrobial activity. The hydroxycinnamic acid derivatives (p-coumaric, feluric, caffeic and chlorogenic acids) found in fruits, vegetables, tea and other plants possess antibacterial and antifungal activity. Also natural covering of foods like shell of eggs and nuts, outer covering of fruits and testa of seeds, hide of animals provide protection against entry and subsequent spoilage by microorganisms.

Extrinsic Parameters

Temperature of storage

Microorganisms have been found growing in virtually all temperatures. A particular microorganism will exhibit a range of temperature over which it can grow, defined by three cardinal points in the same manner as pH. Considering the total span of temperature where liquid water exists, the prokaryotes may be subdivided into several subclasses on the basis of one or another of their cardinal points for growth. For example, organisms with an optimum temperature near 37°C are called mesophiles. Organisms with an optimum temperature between about 45°C and 70°C are thermophiles e.g, Bacillus, Clostridium etc. Some archaebacteria with an optimum temperature of 80°C or higher and a maximum temperature as high as 115°C , are now referred to as extreme thermophiles or hyperthermophiles. The cold-loving organisms are psychrophiles defined by their ability to grow at 0°C. A variant of a psychrophile (which usually has an optimum temperature above 10°C) is a psychrotroph, which grows at below 7°C but displays an optimum temperature in the mesophile range, nearer room temperature. Psychrotrophs are the scourge of food storage in refrigerators since they are invariably brought in from their mesophilic habitats and continue to grow in the refrigerated environment where they spoil the food. Of course, they grow slower at 2°C than at 25°C. In food microbiology mesophilic and psychrotrophic organisms are of greatest importance.

Relative humidity of the storage environment

Relative humidity and water activity are interrelated. When foods with low a W are stored in environment of high humidity, water will transfer from the gas phase to the food and thus increasing aW of the food leading to spoilage by the viable flora. There is a relationship between temperature and humidity which should be kept in mind. In general, the higher the temperature, lower is the relative humidity and vice-versa. Foods that undergo surface spoilage from molds, yeasts, and some bacteria should be stored in conditions of low relative humidity to increase their shelf life. This can also be done by proper wrapping of the food material also. However, variations in storage temperature should be minimal to avoid surface condensation in packed foods.

Gaseous atmosphere

Oxygen is one of the most important gases which come in contact with food influence the redox potential and finally the microbial growth. The inhibitory effect of CO 2 on the growth of microorganisms is applied in modified atmosphere packaging of foods. The storage of foods in atmosphere containing 10% of CO2 is referred to as "Controlled Atmosphere". This type of treatment is applied more commonly in case of fruits such as apples and pears. With regards to the effect of CO2 on microorganisms, molds and Gram-negative bacteria are the most sensitive, while the Gram-positive bacteria, particularly the lactobacilli tend to be more resistant. Some yeasts such as Bretanomyces spp. also show considerable tolerance of high CO2 levels and dominates the spoilage microflora of carbonated beverages. Some microorganisms are killed by prolonged exposure to CO2 but usually its effect is bacteriostatic. Also, the presence of CO2 tends to decrease the pH of foods and thereby inhibiting the microorganisms present in it by adversely affecting the solute transport, inhibition of key enzymes involved in carboxylation/ decarboxylation reactions.

LESSON-21
FOOD SPOILAGE

Introduction

Spoilage of food can be defined as any visible or invisible change which can makes food or product derived from food unacceptable for human consumption. Major causes of food spoilage are enlisted in Table 6.1.

Spoilage of food not only causes health hazard to the consumer but also cause large economic losses. Spoilage not only leads to loss of nutrients from food but also cause change in original flavor and texture. It is estimated that about 25% of total food produced is spoilt due to microbial activities only despite range of preservation methods available. Thus the spoilage of food is not only a health hazard but also carry lot of economic significance too.

In total, the food spoilage is considered a complex phenomena whereby a combination of microbial and biochemical activities take place. Due to such activities, various types of metabolites are formed which aid in spoilage. The detection of these metabolites help in detection of spoilage.

The ease with which foods are spoiled depend upon factors described. The foods are thus divided into different classes as:

Perishable foods

These foods are readily spoilt and require special preservation and storage conditions for use. The foods of this class are mostly used daily such as milk, fruits, vegetables, fish etc.

Semi-perishable foods

This class of foods if properly stored can be used for a long duration e.g. potatoes.

Non-perishable foods

These foods remain in good form for long duration unless handled improperly. It include sugar, flour etc.

Factors Affecting Microbial Spoilage of Foods

While the spoilage by physical and chemical modes play important role, the microbial spoilage has most significant role. Combination of all these factors is ultimately responsible for overall decay of food. The spoilage of food can occur at different stages of production, processing.

The spoilage of foods due to microbial activity initiates when undesirable microorganism colonize the food. Once colonization is established, the microbial community grow on the food constituents, thereby utilizing them for their metabolism. During the course of such microbial activity, the food become unsuitable for human consumption. Various parameters affect the proliferation of microbes. These include intrinsic to food such as water activity, acidity, oxidation-reduction potential, presence of antimicrobial compounds in food and food structure. Extrinsic parameters such as temperature, humidity and other storage condition aid in spoilage.

Microorganisms in Food

Microorganisms by virtue of their ubiquity and diversity in metabolism are most significant cause of food spoilage. Bacteria and fungi (including yeasts and moulds) are major cause of food spoilage.

Bacteria are round; rod or spiral shaped microorganisms and can grow under a wide variety of conditions. There are many types of bacteria that cause spoilage. Food spoiling bacteria are primarily divided two groups viz. spore-forming and nonspore-forming. Bacteria generally grow in low acid foods like vegetables and meat.

Yeasts growth causes fermentation which is the result of yeast metabolism. There are two types of yeasts true yeast and false yeast. True yeast metabolizes sugar producing alcohol and carbon dioxide gas. This is known as fermentation. False yeast grows as a dry film on a food surface, such as on pickle brine. False yeast occurs in foods that have a high sugar or high acid environment.

Molds grow in filaments forming a tough mass which is visible as `mold growth'. Molds form spores which, when dry, float through the air to find suitable conditions where they can start the growth cycle again.

Mold can cause illness, especially if the person is allergic to molds. Usually though, the main symptoms from eating moldy food will be nausea or vomiting from the bad taste and smell of the moldy food.

Both yeasts and molds can easily grow in high acid foods like fruit, tomatoes, jams, jellies and pickles. Both are easily destroyed by heat. Processing high acid foods at a temperature of 100°C (212°F) in boiling water in can for the appropriate length of time destroys yeasts and moulds.

a) Rod shaped Bacteria

b) Mould

c) Yeast

Changes in Foods Due to Microorganisms

As microorganisms grow in food, by virtue of their diversity in metabolism they utilize components of foods and convert them into variety of chemical compounds.

Change in Carbohydrates

Carbohydrates are used to obtain energy. While monosaccharide are preferred over complex carbohydrates, microorganisms have ability to convert polysaccharides to simpler forms before obtaining energy. The utilization of simple sugar such as glucose vary under aerobic and anaerobic conditions. In aerobic conditions it is converted into carbon dioxide and water through glycolysis and other related pathways. In absence of oxygen, the process yields a number of compounds in different organisms. This process is known as fermentation. These compounds include:

Alcoholic fermentation

It occurs due to yeasts and carbon dioxide and ethanol are the major end products.

Lactic fermentation

It is of two types viz. homolactic fermentation where primarily lactic acid is the end product and heterolactic fermentation where along with lactic acid, acetic acid, ethanol, glycerol, carbon dioxide are produced.

Coliform type fermentation

This type of fermentation occur in coliform bacteria. In this process acids such as lactic, acetic, formic. Ethanol, glycerol etc. are produced.

Propionic fermentation

It occurs in propionic bacteria and in it along with propionic acid, succinic acid and carbon dioxide are produced.

Change in Nitrogenous Compounds

Proteins are the major source of nitrogenous compounds in foods. Thus degradation of proteins, include hydrolysis by enzymatic reactions. The source of enzymes can be either microbes or foods own enzymes. Complex proteins are converted into polypeptides, simpler peptides and amino acids. The enzymes involved in conversion of proteins into polypeptide are termed as proteinase while those catalyzing conversion of polypeptides to amino acids are called peptidases. The decomposition of proteins can be aerobic or anaerobic. Usually the anaerobic decomposition of proteins results in obnoxious odors. This process is known as Putrefaction. Along with nitrogenous compounds, other compounds responsible for such smells also include sulfur compounds.

The microbial activity on amino acids cause either deamination (removal of amine group) or decarboxylation (removal of carboxyl group). Major organisms involved in conversion of nitrogenous compounds include Pseudomonas, E. coli, Clostridium, Desulfotomaculum etc.

Changes in Lipids

The hydrolysis of lipids is accomplished by lipase enzymes produced by different microorganisms. The major end products include glycerol and fatty acids, which are further used by microorganisms for their metabolism. The process of conversion is known as oxidation. The oxidation of fats is also done by enzymes of food itself. High fat containing foods are prone to such processes.

Mycotoxins are fungal metabolites that get formed in foods due to the growth of some strains of Pencillium, Aspergillus and some other molds. They are secondary metabolites and are of low molecular weight. They are highly thermo stable and withstand the conventional processing temperatures. They are highly toxic to a large number of animals and also to human beings. The food borne disease resulting from the ingestion of toxin in mold contaminated food is called mycotoxicosis. They affect kidney, liver, cause skin irritation, birth defect and death. They have also been found to be carcinogenic in nature.

Aflatoxins are produced by some strains of Aspergillus flavus and A. parasiticus and they occur in different chemical forms like B1, B2, G1 and G2. Aflatoxin M1 and M2 are the hydroxylated derivatives of B1 and B2. Milch animals fed with aflatoxin B1 and B2, excret aflatoxin M1 and M2, in milk, urine and feces. Aflatoxin B1 is the most toxic among all aflatoxins. However M1 and M2, are relatively less toxic as compared to the parent compounds B1 and B2. Aflatoxins are found in nuts, spices and figs and they are produced under hot and humid conditions during storage.

Viruses are obligate intracellular parasites. They are host specific. Several viruses have been implicated in food borne outbreaks. There are four acute gastro enteritis namely calici virus, rota virus, astro virus and adeno virus. The infectious hepatitis A virus enters a person through the contaminated food or water and it causes gastro enteritis. Viruses responsible for poultry diseases have also been implicated in human aliments.

LESSON-22

PRINCIPLES AND METHODS OF FOOD PRESERVATION

Food preservation can be defined as the science which deals with the process of prevention of decay or spoilage of food thus allowing it to be stored in a safe condition for future use. All foods gradually undergo deterioration or spoilage from the time they are harvested or manufactured. Some commodities spoil rapidly, while others can keep for longer but limited periods.

The basic purposes of food preservation are:

1. Extension of shelf-life of foods thus increasing the supply.
2. Ensuring the availability of seasonal foods throughout the year.
3. Adding variety to the diet.
4. Saving time by reducing preparation time and energy.
5. Stabilizing firm prices and prices of food.
6. Improving the nutritional qualities.

The food spoilage might be due to growth and activity of micro-organisms, insects or rodents, action of enzymes. Chemical reactions and physical changes take place during processing by burning, drying, freezing etc. Depending upon the easiness of spoilage and the level of perishability the foods have been classified into three categories:

Non-perishable or relatively stable
Semi-perishable or protectable
Perishable

1. Non-perishable or relatively stable: The foods that do not spoil easily and can stored for several months unless handled carelessly. They have low moisture content and are not easily susceptible to spoilage by micro-organisms. They include mature food grain, cereals, pulses, nuts, sugar, dry beans etc.

2. Semi-perishable or protectable: These foods can be kept for about a week to a month’s time and remain unspoiled for fairly long period with proper care. They contain comparatively much less level of moisture content and also contain certain natural inhibitors to spoilage such as roots, vegetables and eggs. These include potatoes, flours, roasted oil seeds, biscuits, onions, dried fruits and other dehydrated foods. Some other examples of prepared foods are pasteurized milk, smoked fish and pickled vegetables.

3. Perishable foods: the perishable foods are those which deteriorate/spoil quickly after harvesting and cannot be kept for more than a day or two without affecting their quality. These food stuffs have a higher degree of moisture content and are highly susceptible to spoilage. The typical examples of such foods include most fruit and vegetables, milk, meat, fish and poultry.
Principles of Food Preservation

Prevention or delay of microbial decomposition.

1. By keeping out microorganisms - asepsis
2. By removal of microorganisms - filtration
3. By hindering the growth and activity of microorganisms - low temperature, drying.
4. By killing the microorganisms - heat or radiation.

Prevention or delay of self decomposition of food -By destruction or inactivation of food enzymes, (eg) blanching.

Prevention of damage caused by insects, animals and mechanical causes.

Methods of Food Preservation

All methods used for preserving foods are based upon the general principle of preventing or retarding the causes of spoilage. - microbial decomposition, enzymatic reactions and damage from mechanical causes insects and rodents.

Preservation by low Temperature

i. Freezing

Freezing may preserve foods for long periods of time provided the quality of food is good to begin with and the temperature is maintained in freezers. In slow freezing process or sharp freezing the foods are placed in refrigerated rooms at temperatures ranging from - 4 ^{o}C to 29 ^{o} C. In quick freezing process the lower temperatures used - 32 ^{o} C to -40 ^{o} C freeze foods so rapidly that fine crystals are formed and the time of freezing is greatly reduced over that required in sharp freezing.

ii. Dehydrofreezing

Of fruits and vegetables consists of drying the food to about 50 percent of its original weight and volume and then freezing the food to preserve it.

Preservation by high Temperature

i. Pasteurization

Pasteurization is a heat treatment that kills part but not all the microorganisms present and usually involves the application of temperatures below 100 o C. The heating may be by means of steam, hot water or dry heat and the products are cooled promptly after the heat treatment. Usually milk is pasteurized. Three general methods are used now-a-days.

a. Holding or Batch system (Holder method)

This consists in bringing the milk or cream to a temperature usually 65 ^{o} C and holding at that point for at least 30 minutes followed by rapid cooling.This consists of raising the temperature of the milk to at least 72 o C for 15 seconds followed by quick cooling.

c. Ultra High Temperature System (UHTS)

In this system, milk is held for 3 seconds at 93.4 o C. After pasteurisation the milk is cooled rapidly to 7 o C or lower.

ii. Canning

Canning involves the application of temperatures to food that are high enough to destroy essentially all microorganisms present plus air tight sealing in sterilised containers to prevent to contamination. Fruits, vegetables and flesh foods are preserved by this method.

Preservation Using Preservatives

Preservatives has been defined as chemical agents which serve to retard, hinder or mask undesirable change in food. These changes may be caused by microorganisms, by the enzymes of food or by purely chemical reaction. The PFA classifies them as class I preservatives and class II preservatives. Class I preservatives are salt, sugar spices, vineger, honey and edible vegetable oils. Class II preservatives are benzoic acid and its sodium and potassium salts, sorbic acid and its sodium and potassium salts. The preservatives generally used in fruit and vegetable products may be broadly classified as organic and inorganic preservatives.

The organic preservatives are benzoic acid, chlorobenzoic acid or salicylic acid. The only permitted inorganic preservative is sulphur-di-oxide which is generally used in the form of sulphites. The preservatives permitted in fruit and vegetable products in India are sodium benzoate, sulphites and sorbic acid. Sulphur-di-oxide, sulphites and metabisulphites are used in confectionary, fruits and fruit juices and wines. Sodium or potassium metabisulphites are used in the preservation of fruit products. Sodium benzoate is used as a preservative in grape crushes and tomato ketchup.

Preservation by high Osmotic Pressure

By the principle of osmosis, jams, jellies and pickles are preserved.

i. High Concentration of Sugar

Apples, guavas, grapes and pineapples are suitable for making jams and jellies. For making jams and jellies, the fruit should be just ripe because the pectin content is high in such fruits.

ii. High Concentration of Salt

Salt is used to control microbial population in foods such as butter, cheese, vegetables, meats, fish and bread. Spices and other condiments have bacteriostatic effect. In addition to salt and several spices, oils are used in making pickles. Aerobic bacteria and mould growth are prevented by covering the top with oil. Properly prepared and stored pickles can last upto a year or more without spoilage. The important preservative agents in pickles are salt, vinegar, sugar, oil, spices and condiments.

Preservation by Dehydration

Dried foods are preserved because the available moisture level is so low that microorganisms cannot grow and enzyme activity is controlled. Dehydration processes are used commercially for many foods including dried milks, eggs, coffee, tea, fruit drinks, dessert mixes and traditional dried fruits, vegetables, meat and fish. As a result of heat applied during the drying process many of the organisms present in the food are destroyed. Bacteria require 18% available moisture for their growth, yeast 20% or more and moulds 13-16 %. It is therefore essential in the preservation of food by drying to reduce moisture as much as possible without damaging the essential quality of the food.

Food Irradiation

Food irradiation is a process of food preservation in which food is exposed to ionizing energy - radio isotope cobalt - 60. The potential uses of food irradiation are

To avoid the use of harmful chemical compounds like methyl bromide and ethylene oxide for insect disinfestation in stored products and microbial decontamination of spices.

1. To extend shelf life of meat, poultry and sea foods by killing microorganisms causing their spoilage.

2. To enhance safety of food by killing food borne pathogenic microorganism and parasites.

Food irradiation reduces post harvest storage losses. Irradiation at the appropriate level does not change the flavour, taste, smell, texture and mineral contents of foods. Irradiated foods are safe and wholesome for human consumption.

Preservation by High Temperature

The temperature and time used in heat processing a food depends upon the effects of heat on food and the other pre-servative methods employed.

Pasteurization

Pasteurization is a heat treatment that kills part but not all the micro organisms pres-ent and involves the application of tem-peratures below 100°C. The heating, may be by means of steam, hot water, dry heat or electric currents and the products are cooled immediately after the heat treat-ment. Milk is usually pasteurized.

Pasteurized products are not ster-ile. They contain vegetative organisms and spores which are still capable of growth. Hence many pasteurized foods must be stored under refrigeration. Pasteurized milk can be stored for over a week under refrigeration while pasteurized milk stored at room temperature will spoil within a day.

Table 2 The Time and Temperature for the Pat eurization of Various Food Products

Food	Temperature (°C)	Duration
Milk	62.8	30 mts.
	71.7	15 sec.
Ice cream mix	71.1	30 mts.
	82.2	60–20 secs.
Grape wine	82–85	1 min.
Dried fruits	65.6–85	30–90 mts.
Bottled grape juice	76.7	30–90 mts.
Carbonated juices	65.5	30 mts.

Source: Food Science III Edition, New Age International publishers Srilalshmi. B. (2006), Chennai

Blanching

Blanching is a heat treatment like pasteur-ization. It is done by dipping the products in boiling water for two to three minutes at 180°F to 190°F. Blanching focuses on deaerating the product and inactivating degradative enzymes before further pro-cessing. Blanching is an important step in freezing food, as frozen foods can develop off flavour, vitamin losses and colour changes while in storage.

Blanching

· Prevents bacterial growth.

· Fixes the natural colour of vegetables – holds the colour.

· Shrinks the product, better for filling the container.

Blanching of tomatoes

Canning

Canning involves the application of tem-peratures to food that is high enough to destroy essentially all micro organisms present. It also involves *airtight sealing* in sterilized containers to prevent recontam-ination. The degree of heat and the length of time of heating vary with the type of food and the kinds of micro organisms. Large quantities of food are canned for preservation. In developed countries, canned foods form a major part of the diet of the people. *Items* often canned are *meats and meat products, fruits and vege-tables, fish products, soups, etc.*
The process of canning involves the following steps:

- Receiving, cleaning, grading and inspecting of raw commodity.
- Blanching to inactivate enzymes.

- Placing in the container with added brine or syrup and deaeration of the product.
- The next process is exhausting. Exhaust-ing is done to expel the air and gas from the can so that its internal pressure, after heating and cooling, is the same as the atmospheric pressure.
  - After exhausting, the filled cans are per manently sealed mechanically.

- The sealed containers are subjected to high temperatures, to destroy the most heat resistant organisms.

- After this, the cans are cooled by water in a cooling canal to about 38°C, before storage.

  - The final step is casing and storing the cans.

LESSON 23

FOOD DEHYDRATION AND CONCENTRATION

Introduction

Drying is the oldest method of food preservation. It is a process derived from nature. Microorganisms need free water in order to grow and multiply. During drying, the water content of the food is reduced to critical level below which microorganisms cannot grow.

Difference Between Drying and Dehydration

Both the terms ‘drying’ and ‘dehydration’ mean the removal of water. But the former term is generally used for drying under the influence of non-conventional energy sources like sun and wind whereas dehydration means the process of removal of moisture by the application of artificial heat under controlled conditions of temperature, humidity and air flow.

Difference Between Drying/ Dehydration and Concentration

Drying refers to the removal of relatively low amounts of water from a material as vapour by passing hot air while concentration/ evaporation refers to removal of relatively large amount of water as vapour at its boiling temperature. Concentration is not as effective as drying.

Foods are concentrated or dehydrated for the same purpose. Concentration is applicable in case of liquid foods only.

Principle of Preservation by Drying/ Dehydration/ Concentration

The principle behind drying is that sufficient moisture is removed, which is essential for growth of microorganisms and for enzyme activity. Removal of moisture increases the storage life of the product due to reduced water activity. If the moisture content is reduced to 1 to 5 per cent then the product can be stored for more than a year. The processing should be done in such a way that the food value, natural flavour and characteristic cooking quality of the fresh material are retained after drying. A good dried product on reconstitution with water should resemble the original product.

Advantages of Drying

Preservation is the main reason but not the only reason for dehydrating foods. Food may be dehydrated for other reasons also viz. to decrease weight and bulk; to retain size and shape of original food; to produce convenience items. Dehydration/ drying is advantageous for being cheaper than the other methods of preservation with less requirement of equipments. Storage of dried food products does not require special facilities like refrigeration etc. Dried food products are simple to store and pack because of their low volume.

Dehydrated foods however, are less popular because of some undesirable changes in colour, taste and flavour during storage and distribution. Dehydration techniques have been improved to overcome most of these defects.

Factors in control of drying:

Various factors affecting rate of drying in a fresh produce include the following:

i. Composition of raw materials: Foods containing high amount of sugar or other solutes dry slowly.

ii. Size, shape and arrangement of stacking of produce: Greater the surface area greater is the rate of drying.

iii. Temperature as well as humidity and velocity of air: Greater is the temperature differential between the product and the drying medium faster the product dries. Lower the humidity of environment the faster the drying will be.

iv. Pressure (atmospheric or under vacuum): Lower the atmospheric pressure the lower the temperature required to evaporate water.

v. Heat transfer to surface (conductive, convective and radiative): The fastest method of heat transfer is radiation consecutively followed by convection and conduction.

Types of Drying

Basically, drying can be done by two processes viz. natural drying and mechanical dehydration or artificial drying based on source of energy. Natural drying takes place under the influence of sunlight and wind and is of three types viz. sun, solar and shade drying. In natural drying there is no control over temperature, air flow and humidity whereas in artificial drying, these conditions are well controlled.

Mechanical dehydration or artificial dehydration can be further classified into atmospheric and sub-atmospheric types based on the conditions employed in drying process. On the basis of mode of drying process, drying at atmospheric pressure conditions can be further divided in batch and continuous types. Mechanical drying includes the methods of drying by (1) heated air, (2) direct contact with heated surface e.g. drum drying and (3) application of energy from a radiating microwave or dielectric source.

Commercial dehydrators are generally large in size and various types of dehydrators can be based on circulation of air as (1) Natural and (2) Forced draught. In natural draught, the rising of heated air brings about drying of food in the natural draught method. Examples include kiln, tower and cabinet driers. Forced draught employ currents of heated air that move across the food usually in tunnels. An alternative method is to move the food or a conveyor belt or trays through heated air. Examples include tunnel or belt drier. In forced draught drier, the temperature and humidity can be carefully controlled to get a good dehydrated product but are not in general use because of the cost.

Sun drying:
Drying the food product under natural sunny conditions is called as sun drying. No energy is required for the drying process. To practice sun drying of foods, hot days are desirable with minimum temperatures of 35°C with low humidity. Poor quality produce can not be used for natural drying to achieve good quality dried product. The lower limit of moisture content by this method is approximately 15 per cent. Problems of contamination and intermittent drying are generally encountered with sun drying. It is only possible in areas of low humidity.
Simple equipments are required such as knives, peelers, trays etc. Plastic sheets are also used. Process consists of washing, peeling and preparation of fruit or vegetables. Fruits are generally sulphured whereas vegetables are blanched before drying to prevent enzymatic browning. Fruits are seldom blanched. Fruits are considered to be dry when they show no signs of moisture or stickiness when held firmly in the hand. Vegetables are considered to be dry when they become brittle. At this stage, they should be removed from the dehydrator. The residual moisture in the vegetables should not be more than 6-8 per cent and in fruits 10-20 per cent. Dried fruits can be used as such after soaking, while dried vegetables are usually soaked in water overnight and then cooked.
Solar drying:
Solar drying uses designed structures to collect and enhance solar radiation. Solar driers generate high air temperature and low humidity which results in faster drying. This drier is faster than sun-drying, and also requires less drying area. But it cannot be used on cloudy days. Generally, three types of solar driers are used, as (1) the absorption or hot box type driers in which the product is directly heated by sun, (2) the indirect or convection driers in which the product is exposed to warm air which is heated by means of a solar absorber or heat exchanger and (3) drier, which is combination of first and second type.
Shade drying:
This kind of method is used for foods which lose their colour when exposed to direct sunlight for drying. Generally herbs, green and red chillies, okra and beans etc. are dried under shaded area with good air circulation.
A home scale dehydrator or drier:
It consists of a small galvanized box having dimensions of 90x90x60 cm. The lower portion consists of perforated iron tray. The box is fitted on to a wooden frame which is kept about 2-3 feet above ground. At the top there are two slits which can be closed by shutters. About seven trays can be kept in the drier. The material to be heated is kept on trays and heating source can be a gas stove or any other source. The initial temperature of the dehydrator is usually is 43°C which is gradually increased to 60-66°C in the case of vegetables and 66-71°C for fruits. For a home scale drier 100-200 g of sulphur is required for 25 kg fruit. Time required for drying is generally ½ hour to 2 hours.
Oven drying:
A conventional oven with a thermostatic setting of 60°C is suitable for oven drying of fruits, vegetables, fruit leathers and meats . This is a kind of cabinet drier.
Kiln drier:
Also known as kiln evaporator. It consists of two floors. On the top floor, food to be dried is spread and on the lower floor, the furnace is housed. Heat is conveyed by a ventilator. Generally it is used for large pieces of food.
Tower drier:

It is also called as stack type drier. This drier consists of a furnace room containing the furnace, heating pipes and cabinet in which fruits are kept in perforated trays. Heated air from the furnace rises through the trays. Heating is through steam coils placed between the trays. The trays are interchanged as drying progresses.

Spray drying:

Spray drier is used to dry purees, low viscosity pastes and liquids, which can be atomized. The material is sprayed in a rapidly moving current of hot air. The dried product drops to the bottom of the drying chamber and is collected. Atomization into minute droplets results in drying in a matter of seconds with common inlet air temperature of about 200°C and properly designed system quickly removes the dried particles from heated zones. This method of dehydration can produce exceptionally high quality with many highly heat sensitive materials including milk and coffee.

Drum or roller drying:

Foods in the form of puree and liquid are dried using this method. This kind of processing is used for preparation of mango flakes, orange flakes, baby foods etc. The pulp of fruit is blended with a small quantity of edible starch and then the blend is adjusted for acidity. The mixture is poured little by little on to heated drum which are made of stainless steel. Drums are revolving at a slow speed. The product dries in the form of a continuous thin sheet or powder. This is broken into small pieces which are then collected in a tin container. Lid has to be placed immediately because the flakes are highly hygroscopic. Drum drying is one of the most energy efficient drying methods and is particularly effective for drying high viscous liquid or pureed foods.

Microwave drying:

In this method, microwaves are used to dry the food product.

Freeze drying:

Foods in the pieces and liquids are dried by this method. Fruit juice concentrates are manufactured using freeze drying. The material is frozen on trays and then dried under vacuum. Due to vacuum drying, the material dries directly without passing through the intermediate liquid stage. The principle behind freeze drying is that under certain conditions of low vapour pressure, water can evaporate from ice without the ice melting.

Freeze drying is generally used to dry sensitive and high value liquid as well as solid foods such as juices, coffee, strawberries, chicken dice, mushroom slices etc. The dried product is highly hygroscopic and reconstitutes readily. Taste, flavour and reconstitution property of fruit juice concentrates is excellent. Method is costly because of the equipment cost. Freeze drying in combination with air drying is advantageous in reducing cost of drying. For example- vegetables pieces may be air dried to about 50 per cent moisture and then freeze dried down to 2-3 per cent moisture.

Accelerated freeze drying (AFD):

This is used for drying pieces of food material without disturbing their shape and texture. Product has good reconstitution property, taste and flavour. The pieces of material are kept pressed between two perforated or wire mesh trays inside a cabinet freeze drier. As the material dries, the bulk of the pieces is gradually reduced by decreasing the clearance between the trays is reduced. The dried material retains its shape and regains it on rehydration. Meat etc. are dried using this technique.

LESSON-24
PRESERVATION BY HIGH AND LOW TEMPERATURE

PRINCIPLES OF FOOD PRESERVATION BY HEAT

Application of heat to the foods leads to the destruction of microorganisms. The specifictreatment varies with:
i) The organisms that has to be killed.
ii) The nature of the food to be preserved and
iii) Other means of preservation that may be used in addition to high temperature.
High temperatures used for preservation are usually:
(1) Pasteurization temperature – below100^{o}C (2) Heating at about 100^{o}C and (3) Sterilization temperature above 100^{o}C.

a. Pasteurization–below 100^{o}C

Pasteurization is a heat treatment that kills part but not all the microorganisms presentand the temperature applied is below 100^{o}C. The heating may be by means of steam, hot H_2O,dry heat or electric currents and the products are cooled promptly after the heat treatments. Thesurviving microorganisms are inhibited by low temperature (or) some other preservative methodif spoilage is to be prevented.
Preservative methods used to supplement pasteurization include
(i)refrigeration e.g. of milk (2) keeping out microorganisms usually by packaging the product in asealed container (3) maintenance of anaerobic conditions as in evacuated, sealed containers
(4) addition of high concentration of sugar, as in sweetened condensed milk and
Methods of pasteurization
HTST method - High temperature and short time (above 70^{o}C)
LTH method - Low temperature and higher time (or) Holding method (60-70^{o}C)

b. Heating at about 100^{o}C

A temperature of approximately 100^{o}C is obtained by boiling a liquid food, by immersionof the container of food in boiling water or by exposure to flowing steam. Some very acid foods,e.g., sauerkraut may be preheated to a temperature somewhat below 100^{o}C, packaged hot, andnot further heat processed. Blanching fresh vegetables before freezing or drying involvesheating briefly at about 100^{o}C.

c. Sterilization-above 100^{o}C

By this method all microorganisms are completely destroyed due to high temperature.The time and temperature, necessary for sterilization vary with the type of food. Temperaturesabove 100oC can only be obtained by using steam pressure sterilizers such as pressurecookers and autoclaves.

Fruits and tomato products should be noted at 100^{o}C for 30 min. so that the sporeforming bacteria which are sensitive to high acidity may be completely killed. Vegetables likegreen peas, okra, beans, etc. being non acidic and containing more starch than sugar, requirehigher temperature to kill the spore forming organisms. Continuous heating for 30-90 min. at116^{o}C is essential for their sterilization. Before using, empty cans and bottles should also besterilized for about 30 min. by placing them in boiling water.
Difference between pasteurization and sterilization

Pasteurization	Sterilization
. Partial destruction of microorganism	Complete destruction of microorganism

Temperature below 100^{o}C	Temperature 100^{o}C and above
Normally used for fruits	Normally used for vegetables

Aseptic canning

It is a technique in which food is sterilized outside the can and then aseptically placed inpreviously sterilized cans which are subsequently sealed in an aseptic environment.

Hot Pack (or) Hot fill

Filling of previously pasteurized or sterilized foods, while still hot, into clean but notnecessarily sterile containers, under clean but not necessarily aseptic conditions.

PRESERVATION BY LOW TEMPERATURE

Microbial growth and enzyme reactions are retarded in foods stored at low temperature.The lower the temperature, the greater the retardation. Low temperature can be produced by

(a) Cellar storage (about 15^{o}C)

The temperature in cellar (underground rooms) where surplus food is stored in manyvillages is usually not much below that of the outside air and is seldom lower than 15^{o}C. It is notenough to prevent the action of many spoilage organisms or of plant enzymes. Root crops,potatoes, cabbage, apples, onions and similar foods can be stored for limited periods during thewinter months.

(b) Refrigerated (or) chilling (0 to 5^{o}C)

Chilling temperature are obtained and maintained by means of ice or mechanicalrefrigeration. It may be used as the main preservative method for foods or for temporarypreservation until some other preservative process is applied. Most perishable foods, includingeggs, dairy products, meats, sea foods, vegetables and fruits, may be held in chilling storage fora limited time with little change from their original condition. Enzymatic and microbial changes inthe foods are not prevented but are slowed considerably.

Factors to be considered in connection with chilling storage include the temperature ofchilling, the relative humidity, air velocity and composition of the atmosphere in the store room,and the possible use of ultra violet rays or other radiations.

LESSON-25

PRESERVATION BY CHEMICAL PRESERVATIVES

Introduction

Chemical preservation of perishable foods by various additives or preservatives is a significant part of the food preservation industry which is used in combination with other forms of preservation like freezing, canning, dehydration etc. Chemically preserved food products like squashes and crushes etc. can be kept for a fairly long time even after opening the seal of the bottle. It is however essential that the use of chemicals is properly controlled as their indiscriminate use is likely to be harmful. These should be added in very low quantities so that organoleptic and physico-chemical properties of the foods are not altered at all or only a little.

Preservation Principle

Food preservatives interfere with the mechanism of cell division, permeability of cell membrane and activity of enzymes and inhibit the spoilage factors. These work either as direct microbial poisons or by reducing the pH to a level of acidity that prevents the growth of microorganisms.

Definition of Food Preservative

Preservatives are the chemical agents which serve to retard, hinder or mask undesirable changes in food. More precisely, preservatives are substances when added to food to retard, inhibit or arrest the activity of microorganisms such as decomposition of food or of masking any of the evidence of putrefaction but it does not include salt, sugar, vinegar, glycerol, alcohol, spices, essential oils etc.

According to Prevention of Food Adulteration (PFA) Act (1954) and Food Standards and Safety Act (FSSA) of 2006, a 'preservative' means a substance which when added to food, is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food.

Preservatives may be anti-microbial preservatives, which inhibit the growth of bacteria and fungi, or antioxidants such as oxygen absorbers, which inhibit the oxidation of food constituents. Common anti-microbial preservatives include calcium propionate, sodium nitrate, sodium nitrite and sulfites (sulfur dioxide, sodium bisulphite, potassium hydrogen sulphite, etc.) and ethylenediamine tetraacetic acid (EDTA). Antioxidants include butylated hydroxy anisole (BHA) and butylated hydroxy toluene (BHT).

Sulphur dioxide (including sulphites) and benzoic acid (including benzoates) are among the principle preservatives used in the food processing industry.

Classes of preservatives

Under PFA (1954) and FSSA (2006), preservatives are classified into two classes Class I and Class II preservatives

Class I preservatives include mainly natural products which are used comparatively in higher concentrations than class II preservatives. There is no restriction to the addition of Class I preservatives to any food. For example- common salt, sugar, dextrose, spices, vinegar or acetic acid, honey, vegetable oils etc.

Class II preservatives are generally synthetic chemicals used in small quantities. Use of more than one class II preservatives is prohibited. For instance- benzoic acid and its salts, sulphur dioxide and the salts of sulphurous acid, nitrites and nitrates, sorbic acid and its salts, propionic acid and its salts, lactic acid and its salts, methyl or propyl parahydroxy benzoic acid, sodium diacetate are used.

The permitted usage levels of various chemical preservatives in different preserved food products are given in Table 1.

Table 1. Permitted usage levels of chemical preservatives in foods

Chemical preservative	Concentration (ppm)	Foods
Sorbic acid and its salts (calculated as sorbic acid)	50	Nectars, ready to serve beverages in bottles/pouches selling through dispenser
	100	Fruit juice concentrates with preservatives for conversion in juices, nectars for ready to serve beverages in bottles/ pouches selling through dispensers
	200	Fruit juices (tin , bottles or pouches)
	500	Jams, jellies, marmalades, preserve, crystallized glazed or candied fruits including candied peels fruit bars
Benzoic acid and its salts	120	Ready to serve beverages
	200	Jam , marmalade, preserve canned cherry and fruit jelly
	250	Pickles and chutneys made from fruits or vegetables
	600	Squashes, crushes fruit syrups, cordials, fruit juices and barley water or to be used after dilution; Syrups and sherbets
	750	Tomato and other sauces; Tomato puree and paste
Sulphur dioxide	40	Jam , marmalade, preserve canned cherry and fruit jelly
	150	Crystallized glace or cured fruit (including candied peel)
	350	Squashes, crushes fruit syrups, cordials, fruit juices and barley water or to be used after dilution; Syrups and sherbets; Fruit and fruit pulp
	2000	Dehydrated vegetables
Sodium and/ or Potassium nitrite expressed as Sodium nitrite	200	Pickled meat

Lactic acid	No limit	Fermented meat, dairy and vegetable products, sauces and dressings, drinks.
Citric acid	No limit	Fruit juices; jams; other sugar preserves
Acetic acid	No limit	Vegetable pickles; other vegetable sauces, chutney

Source: FSSA (2006) and Garg et al. (2010)

Benzoic Acid and Related Compounds

Benzoic Acid and Related Compounds

Sodium benzoate was the first chemical preservative permitted in foods by the FDA, and it continues to be widely used in large number of foods. Benzoic acid and its related compounds possess antimicrobial activity and their antibacterial action increases in the presence of CO2 and acid. For example- Bacillus subtilis cannot survive in benzoic acid solution in the presence of CO2.

As used in acidic foods, these act essentially as a mould and yeast inhibitor. In fact, benzoic acid is more effective against yeasts than against moulds. It does not stop lactic acid and acetic acid fermentation. Benzoates have greatest activity at low pH especially in food products with pH below 4.5. Optimum functionality occurs between 2.5 and 4.0 pH. Benzoic acid is mostly used in coloured products of tomato,phalsa, jamun, pomegranate, strawberry, coloured grapes etc. as in the long run, it may darken the product.

Sodium benzoate, sodium salt of benzoic acid, is very effective as it is nearly 180 times more soluble in water than benzoic acid. It produces benzoic acid when dissolved in water. It should be used at low levels to avoid possible off-flavours in some products. The maximum level allowable by PFA act is 0.075 per cent. It is used in fruit products, jams, relishes, beverages etc. and is effective against yeasts, some bacteria (food borne pathogens but not spoilage bacteria) and some moulds.

Sorbic acid and related compounds
Sorbic acid and related compounds have antimicrobial properties. They are available as sorbic acid, potassium sorbate, sodium sorbate or calcium sorbate. Salts of sorbic acid are used in many cases as they are highly soluble in water and produce sorbic acid when dissolved in water. The potassium salt of sorbic acid i.e. potassium sorbate is much more soluble in water than the acid. It does not impart any noticeable flavour at normal usage concentrations. Maximum level allowable by PFA act is 0.3 per cent. It is effective up to pH 6.5 but effectiveness increases as the pH decreases. It has about 74 per cent of the antimicrobial activity of the sorbic acid, thus it is required in higher concentrations than pure sorbic acid. It is effective against yeasts, moulds, and select bacteria, and is widely used at 0.025 to 0.10 per cent levels in cheese, beverages, fermented and acidified vegetables,

smoked and salted fish. In wine processing, sorbates are used to prevent refermentation.

Propionic Acid and Related Compounds

Propionic Acid and Related Compounds

Propionic acid is inhibits mould and rope bacteria growth but negligible effect on yeast. Propionic acid and its salts, sodium and calcium propionates, are approved by USFDA as GRAS (Generally Recognized As Safe) substances for food use and also by PFA act in India. Propionates are effective up to maximum limit of 5.5 pH. They are used in preserving cheese, non-alcoholic beverages, jams and jellies. Typical usage level of propionic acid and propionates is 0.2 per cent.

Parabens

The parabens are alkyl esters of para-hydroxy benzoic acid. The two most common esters are methyl and propyl parabens approved by USFDA as GRAS. PFA act has mentioned it among the class II preservatives. The maximum concentration allowed is 0.1 per cent. They are most active against yeasts and moulds (0.5-0.1 per cent) but ineffective against bacteria, especially gram negative bacteria.

Solubility of parabens increases with increase in temperature of water. Methyl paraben is more soluble in water but less effective against moulds than propyl paraben. Therefore, a mixture of methyl paraben (2 to 3 parts) with propyl paraben (1 part) is normally used to negate the difference in their solubility.

Parabens are effective at higher pH values from 3 to 8 and also stable at low and high temperatures, even up to steam sterilization. But they are not as widely used due to high cost and objectionable flavour. They are used in beverages, jams, jellies, preserves, smoked fish and pickles.

Lactic acid

Lactic acid is formed by microbial fermentation of sugars in preserved food products such as sauerkraut and pickles. The acid produced decreases the pH to levels unfavourable for growth of spoilage organisms such as putrefactive anaerobes and butyric-acid-producing bacteria. It does not control yeasts and mould growth, which can grow at such pH levels. Inclusion of other preservatives such as sorbate and benzoate may be used in that case.

Acetic acid

It is also known as vinegar. Acetic acid is a general preservative inhibiting many species of bacteria, yeasts and to a lesser extent moulds. It is also a product of the lactic-acid fermentation. It is more effective in preservative action than lactic acid at same pH levels. It is mainly used in products such as pickles, sauces and ketchup.

Sulphur dioxide and sulphites

Sulphur dioxide and its derivatives have been widely used in foods as a food preservative. It serves both as an antioxidant and reducing agent and prevents enzymatic and non-enzymatic reactions, leading to microbial stability. The common used forms are sulphur dioxide gas and sodium, potassium and calcium salts of sulphite, bisulphite or metabisulphite, which are powders. Various sulphite forms dissolve in water and yield 50 to 68 per cent sulphur dioxide gas. It has bactericidal and bacteriostatic properties and is more effective against bacteria especially gram negative bacteria than moulds and yeasts.

Sulphur dioxide gas (SO2) is one of the oldest known fumigant and a wine preservative. The gaseous form is produced either by burning sulphur or by its release from the compressed liquefied form. It is a colourless, suffocating, pungent-smelling, non-flammable gas and highly soluble in cold water.

Sulphites are effective in producing more SO2 ions at pH values less than 4.0. Metabisulphite are more stable to oxidation than bisulphites and the latter show greater stability than sulphites.

Sulphites inhibit microbial growth by reacting with the energy rich compound like adenosine triphosphate; inhibiting some metabolic pathways; and blocking cellular transport systems. Sulphur dioxide also inhibits browning, both enzymatic and nonenzymatic, reactions in fruits and prevents darkening of colour and alterations of flavour. Therefore, sulphites are used to prevent or reduce discolouration of light-coloured fruits and vegetables, such as dried apples and dehydrated potatoes. These are added to sun-dried tomatoes, dried apricots, dried potatoes and lemon juice. These are also commonly used to lengthen the life of fruit juices.

They are also used in wine-making because they inhibit only bacterial growth but do not interfere with the desired development of yeast. Potassium metabisulphite (KMS) is generally used in non-coloured products whereas in coloured products containing anthocyanin pigment, sodium benzoate is used to prevent discolouration.

USFDA prohibits the use of sulphites in foods as it destroys thiamin (vitamin B1) and also causes severe allergic reactions, especially in asthmatics though, for the majority of the population, they are safe.

Nitrites and Nitrates

Nitrites have been used in meat curing for many centuries. It is used along with a mixture of salt, sugar, spices, and ascorbate for curing meats. Nitrite contributes to the development of the characteristic colour, flavour and texture improvement in addition to preservative effects. Sodium nitrite is quite soluble in water and is more effective below neutral pH (below 7.0). Along with salt, nitrite exhibits stronger antimicrobial action.

Nitrates break down in the body to nitrites and this stops the growth of bacteria, especially Clostridium botulinum, the bacteria that cause botulism poisoning. This is the reason nitrites and nitrates are used mainly among the packaged meats.

Nitrites also stabilize the red colour in cured meat and stop it from turning grey. Nitrates get readily converted into nitrites, which then react with the protein myoglobin to form nitric oxide myoglobin. During cooking, this is converted to nitrosohemochrome, a stable pink pigment, which impart a pink, fresh hue to cured meat. This chemical stabilizes the red colour of the meat and gives an appearance of fresh meat. That is why nitrites are a preferred preservative of meat processors even though its excess use is restricted in many countries.

Nitrite salts should be used with precaution because they can react with certain amines in food at acidic pH to produce nitrosamines, which are known to cause cancer by giving rise to compounds like nitrodimethyl-amine. Addition of sodium ascorbate inhibits nitrosamine formation and reduces the problem of nitrosamines. Nitrites and nitrates are permitted as preservatives in cured meat and meat products including poultry at levels below 200 ppm by USFDA and FSSA in India.

Antibiotics

Antibiotics are antimicrobial substances produced by microorganisms have been allowed for food use only in recent years. But they are not widely used in food preservation due to the risk of ill effects on consumer and possibility of appearance of resistant strains. However, nisin and have been permitted in some foods.

Nisin

Nisin is a polypeptide produced by Steptrococcus lactis (now called Lactococcus lactis). Its solubility depends on the pH of the medium and it is more soluble in acidic pH. Its antimicrobial action increases as the pH decreases. Nisin has a narrow spectrum affecting only gram-positive bacteria, including lactic acid bacteria, streptococci, bacilli, and clostridia. It does not inhibit gram-negative bacteria, yeasts or moulds. Nisin has been permitted in processed cheese up to 12.5 ppm under FSSA.

Natamycin

Natamycin is produced by the bacterium Streptomyces natalensis. The compound has a large lactone ring which is substituted with one or more sugar residues. Natamycin is primarily effective against yeast and moulds and is ineffective against bacteria. It has been permitted for surface treatment of hard cheese under FSSA with maximum level of application not to exceed 2mg/dm3

Ethylenediamine tetra acetic acid (EDTA)

Ethylenediamine Tetra Acetic Acid (EDTA)

EDTA is a metal-chelating agent which removes the metal cofactors that many enzymes need, thus preventing the food spoilage. But, it is not mentioned under FSSA as preservative.

Antioxidant preservatives

Antioxidant preservatives prevent foods from becoming rancid, browning, or developing black spots by suppressing the reaction that occurs when foods combine with oxygen in the presence of light, heat, and some metals. Antioxidants also minimize the damage to some essential amino acids and loss of some vitamins. Antioxidant preservatives, such as butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), tert-butylhydroquinone (TBHQ), and propyl gallate (PG), stop the chemical breakdown of food that happens in the presence of oxygen by inhibiting the free radicals that help initiate and propagate these reactions.

LESSON 26
FOOD IRRADIATION

Introduction

Food irradiation is a physical process of subjecting foods to short wave radiation energy in order to preserve them by sterilization, disinfestation or disinfection. Irradiation is considered a more effective and appropriate technology to destroy food borne pathogens as compared to heat or chemical preservation.

What is food irradiation?

Food irradiation is the process of exposing food to controlled levels of ionizing radiation to kill harmful bacteria, pests, or parasites, or to preserve its freshness. It is also called cold pasteurization as it kills harmful bacteria without heat.

Mode of Action

Irradiation can directly impair critical cell functions or components like DNA and indirectly form radiolytic products/ free radicals from water, which are responsible for 90 per cent of DNA damage. Irradiation results in a variety of changes in living cells based on the dosage. For example- high doses kill microbes/ insects; low doses destroy some of the enzymes that lead to fruit ripening, thereby, delaying it and it also interfere with cell division, thereby limiting/ preventing the reproduction of microbes, insects, parasites, etc.

Radiation In Food Preservation

Ionizing radiation is the radiation with enough energy to remove electron(s) from atoms and molecules and to convert them to electrically-charged particles called ions. But, at dose levels approved for food irradiation, these radiations cannot penetrate nuclei and thus, food can never become radioactive. Other types of radiation energy i.e. infrared and microwaves are non-ionizing radiations with longer wavelengths. Infrared radiation is used in conventional cooking. Microwaves, due to their relatively longer wavelength, have lower energy levels but are strong enough to move molecules and generate heat through friction. Three types of ionizing radiations are approved to be used for food irradiation.

- Electron beams generated from machine sources operate at a maximum energy of 10 million electron volts (MeV).

- X-rays generated from machine sources operate at a maximum energy of 5 MeV.
- Gamma rays are emitted from Co-60 or Ce-137 with respective energies of 1.33 and 0.67 MeV.

Electron beams
Electron beams are the streams of very fast moving electrons produced in electron accelerators. Electron beams have a selective application in food irradiation as they can penetrate only one and one half inches deep into the food commodity. Due to poor penetration, shipping cartons (pre-packed bulk food commodities) are not irradiated with electron beams. Electron beams can be switched on or off at will and require shielding as they are generated through machine sources.

X-rays
Just like electron beams, X-rays are also generated through machine sources. X-rays are photons and have much better penetration and are able to penetrate through whole cartons of food products. X-rays also can be switched on or off at will and therefore, require shielding.

Gamma rays
Gamma rays are produced from radioisotopes either Cobalt-60 (Co-60) or Cesium-137 (Ce-137). Contrary to electron beams and X-rays, radioisotopes cannot be switched off or on at will and they keep on emitting gamma rays, therefore radioisotopes require shielding. Co-60 source is kept immersed under water when it is not in use and Ce-137 is shielded in lead. Due to their continuous operation, radioisotopes need to be replenished from time to time. Gamma rays are photons and have deep penetration ability.

Units of irradiation
Radiation dose is the quantity of radiation energy absorbed by the food as it passes through the radiation field during processing. The gray (Gy) is the unit used to measure absorbed dose of radiation and is equal to one joule of energy absorbed per kg of matter being irradiated.

1 Gy (Gray) = 100 rad (radiation absorbed dose)
1 Kilogray (kGy) = 1000 Gy

International health and safety authorities have endorsed the safety of irradiation for all foods up to a dose level of 10 kGy. Recent evaluation of an international expert study group appointed by Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA) showed that food treated according to good manufacturing practices (GMPs) at any dose above 10 kGy is also safe for consumption, making irradiation parallel to heat treatment of food. In India, the Ministry of Health and Family Welfare amended the Prevention of Food Adulteration Rules (1954) through a Gazette notification dated August 9, 1994, permitting irradiation of onion, potato and spices for internal marketing and consumption. In 1998 a number of other food items were permitted for radiation processing . Approval for additional items like fresh, frozen and dried sea foods and pulses have been given under FSSA regulations (2011).

Food items approved for radiation preservation under PFA Rules, 1955 and FSSA regulations, 2011

Name of food	**Purpose**	**Dose (kGy)**	
		Minimum	**Maximum**
Onion	Sprout inhibition	0.03	0.09
Potato		0.06	0.15
Ginger, garlic and shallots (Small onion)		0.03	0.15
Mango	Disinfestation	0.25	0.75
Rice		0.25	1.00
Semolina (sooji, rawa), wheat atta and maida		0.25	1.0
Raisin, figs and dried dates		0.25	0.75
Meat and meat products including chicken	Shelf-life extension and pathogen control	2.5	4
Spices	Microbial decontamination	6	14
Fresh sea foods	Shelf-life extension and pathogen control	1.0	3.0
Frozen sea foods		4.0	6.0
Dried sea foods	Disinfestation	0.25	1.0
Pulses			

Source: http://www.barc.ernet.in/bmg/ftd/index.html and FSSA regulations (2011)

The advantages and disadvantages of food irradiation are enlisted in .

Advantages and disadvantages of food Irradiation:

Benefits	**Limitations**
Radiation processing does not change texture and freshness of food, unlike heat. In fact, it is difficult to distinguish between irradiated and non-irradiated food on the basis of colour, flavour, taste, aroma or appearance.	Radiation processing cannot be applied to all kinds of foods.
Radiation processing does not affect significantly nutritional value, flavour, texture and appearance of food.	Radiation processing cannot make a bad or spoiled food look good i.e. it is not a magic wand.
Radiation cannot induce any radioactivity in food and does not leave any harmful or toxic radioactive residues on foods as is the case with chemical fumigants.	It cannot destroy already present pesticides and toxins in foods.
It is a very effective method due to its highly penetrating nature of the radiation energy and can be used on packed food commodities.	Compliance of a particular food commodity to radiation processing has to be tested first in a laboratory.
Prepackaged foods can be made sterile thus improving shelf-life.	Only those foods for which specific benefits are achieved by applying appropriate doses and those duly permitted under the PFA Rules, (1955) and now FSSA regulations (2011) can be processed by radiation.
The radiation processing facilities are environment friendly and are safe to workers and public around.	--

Source: http://www.barc.ernet.in/bmg/ftd/index.html

LESSON-27

MALNUTRITION

Good Nutrition:

Normal nutrition implies a balance that avoids deficiency of intake, on one hand and excessive intake on the other (**fig**).

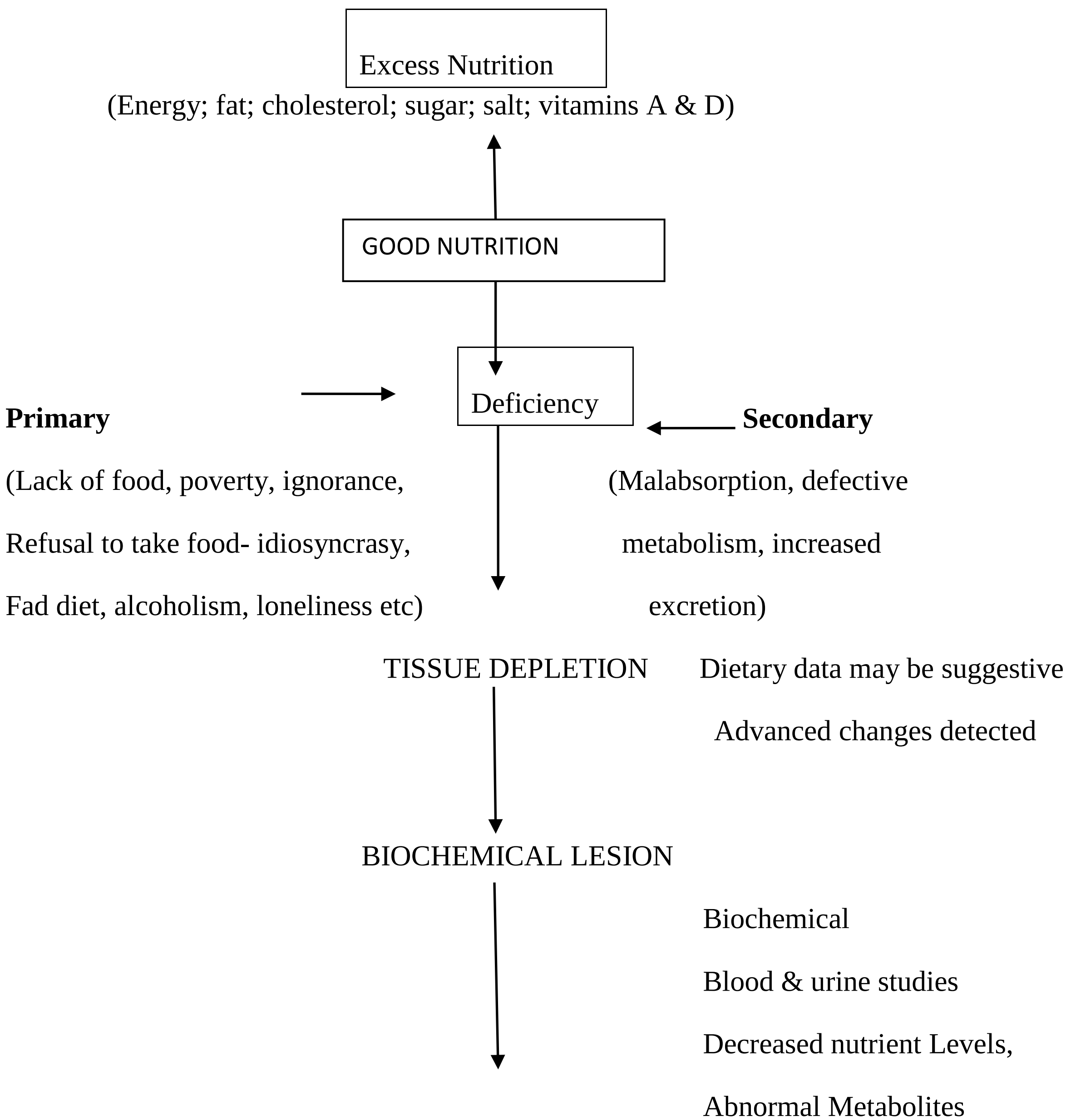


Fig: Effect of malnutrition in the bodyCLINICAL SIGNS.

Achieve nutritional balance:

- It must furnish appropriate levels of all nutrients to meet the physiologic and biochemical needs of the body at all stages of life cycle.
- It must avoid excess of calories, fat, sugar, salt and alcohol associated with increased risk of diet related diseases.

Therefore a good diet should fulfil the above criteria.

Under nutrition Definition

The term malnutrition includes both under nutrition and over nutrition.

Under nutrition is caused by eating too little or an unbalanced diet that does not contain all nutrients necessary for good nutritional status. Under nutrition is due to inadequate energy, protein and micronutrients to meet basic requirements for body maintenance, growth and development.

The direct effect of under nutrition are, occurrence of frank and subclinical nutritional deficiency diseases. The indirect effects are a high morbidity and mortality among young children, retarded physical and mental growth, lowered vitality leading to lowered productivity and reduced life expectancy. The high rate of maternal mortality, still births and low birth weight are all associated with under nutrition.

The health hazards from over nutrition are high incidence of obesity, diabetes mellitus, hypertension, cardiovascular and renal diseases, disorders of liver gall bladder etc.

Effects of under nutrition in different age groups

a) Young children

Research studies revealed that under nutrition during early childhood, can lead to stunting of physical growth, which cannot be corrected even with good diet at later years of life. Under nutrition is associated with sub-optimal intellectual development and neuro integrative competence in children. Even in later life, their mental performance continues to be low.

The major nutritional deficiency signs among preschool children are protein energy malnutrition (PEM), Vitamin A deficiency and vitamin B complex deficiency. Recent NNMB survey of rural children has shown that only about 20% of children are normal with weight above 90 per cent of the standard. A majority of them exhibited mild or moderate malnutrition, while 5.0 per cent of children are severely malnourished.

b) Pregnant and lactating women

Nutritional status of pregnant women influence the condition of offspring at birth. If pregnant women subsists on inadequate diet, maternal malnutrition leads to high incidence of premature birth, low birth weight and high neonatal and maternal mortality. Children born with low reserves of iron and vitamin A are more prone to diseases.

Anemia is a burning problem in pregnant and lactating women, Incidence of low birth weight infant, child and maternal mortality rates are high in India.

c) **Men and women**

National Nutrition Monitoring Bureau (NNMB) data reveals that only about half the adult population in India have normal nutritional status, while the rest suffer from different degree of Chronic Energy Deficiency (CED).

Under nutrition affects the work capacity and in turn, it reduces the productivity of the individual. Iodine deficiency disorders (IDD) is also a public health problem. Sample surveys conducted by the Directorate General of Health Services in 216 districts of 25 states in India have identified 186 districts as IDD endemic with a goiter rate of over 10 per cent.

As per the results of these surveys, no state in India is free from iodine deficiency; 167 million people are considered to be at risk of IDD of whom 54 million have goiter.

A hungry man is a social liability. He cannot work, cannot learn, cannot build up resistance to diseases and hence retards economic and social development of the nation. Thus malnutrition has enormous socio-economic implications affecting not only the personal development but the development of the country.

PEM definition

PEM is a consequence not only of inadequate food intake but also of

1. Poor living conditions.
2. Unhygienic environment
3. Lack of health care.

It is primarily of socioeconomic inequalities and mal distribution of food and health.

The WHO defined protein energy malnutrition (PEM) as a range of pathological conditions arising from co-incident lack in varying proportions of proteins and energy occurring most frequently in infant and young children commonly associated with infection (WHO 1972). The intensity of pathological condition of PEM ranges from mild to moderate to severe degrees.

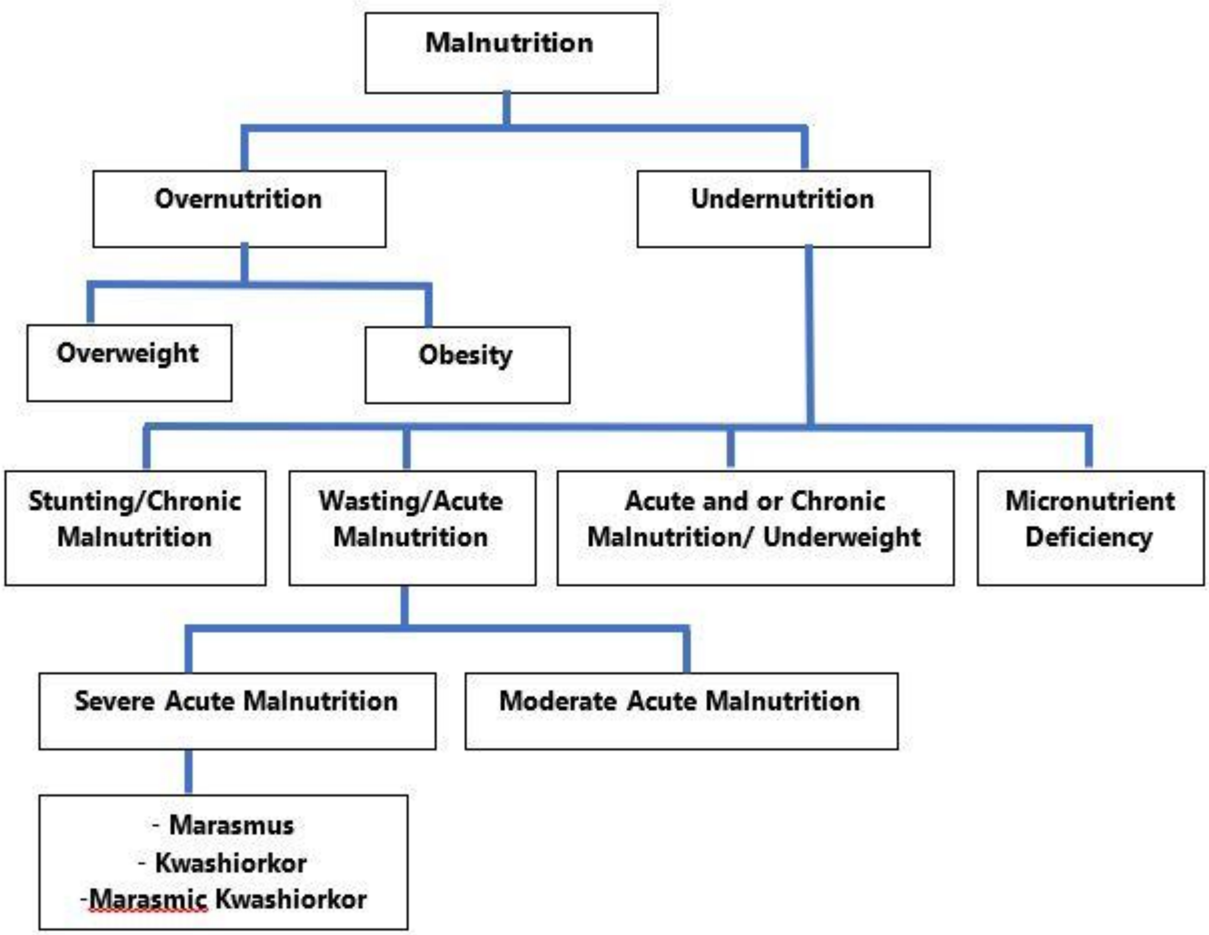
The term kwashiorkor was first introduced by Cicely Williams in 1935. This is local name used by the Ga tribe in Accra, West Africa, ghana and means “disease of the displaced child”. PEM is due to inadequate intake of food and is not due to lack of dietary protein alone.

Protein Energy Malnutrition is a major public health problem in many developing countries and it continues to be a major public health problem. It affects mostly children below 5 years of age of poor under privilege communities. Condition is serious during postweaning stage and is often associated with infection. Respiratory infections and diarrohoea precipitates severe PEM and death.

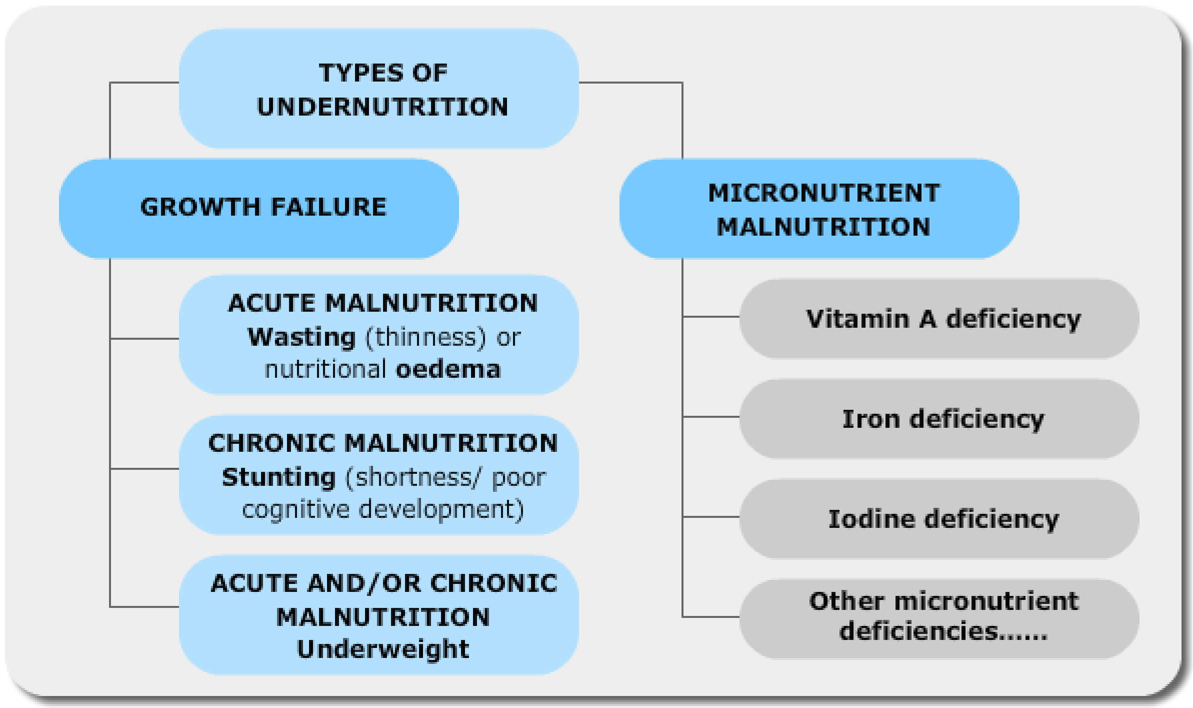
The term protein energy malnutrition covers a wide spectrum of clinical stages ranging from severe forms like kwashiorkor and marasmus to milder forms in which main detectable manifestation is growth retardation. Oedema is the striking feature of kwashiorkor, while severe growth retardation and wasting are the cardinal features of marasmus. Combined forms showing oedema and wasting is described as marasmic kwashiorkor.

Classification of PEM

Classification of PEM (FAO/WHO)



Furthermore, under nutrition can also be classified into two types; 1. Growth Failure 2. Micro-nutrient malnutrition:



Effects of PEM:

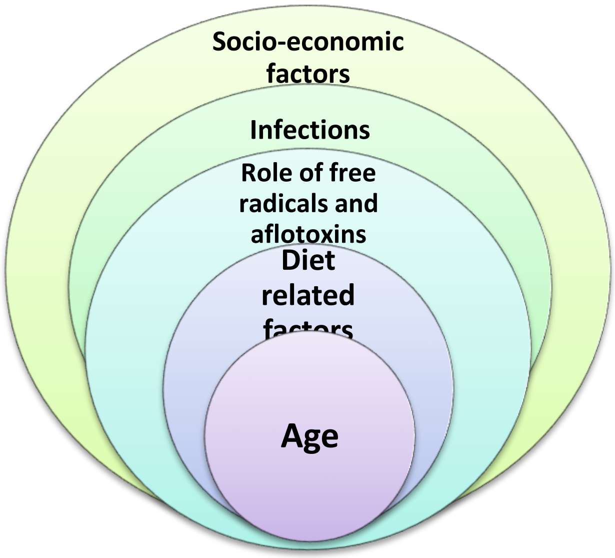
- It contributes to high child mortality & morbidity.
- Stunted growth
- Poor learning ability
- Reduced work efficiency

Thus PEM has serious repercussion on human development and national productivity.

Prevalance of protein energy malnutrition:

- PEM is still the most common nutritional disorder among children in developing countries.
- Surveys carried out by NNMB in different states in India showed significant decline in the prevalence of severe (Grade III) malnutrition. A decline from 15% in 1975-79 to 5% in 2006-07, with corresponding increase in proportion of moderate (grade II) malnutrition.
- The prevalence of clinical forms of PEM have been reduced to less than 1%.
- Hospitals admissions due to PEM have come down considerably.

Aetiology:



1. **Age:** Preschool age children are most seriously affected because of their increased nutritional requirements compared to adults.
   - Infections occur more frequently in this age group.
   - The long term intake of insufficient food can result in marasmus before one year.
   - Kwashiorkor is common after 18 months.

2. **Diet related factors:**
   - Diluted milk formula which is grossely deficient in energy.
   - Prolonged breast feeding
   - Delayed introduction and inadequate amount of supplementary feeds.
   - Introduction of adult diet after prolonged breast feeding. Inability of child to eat sufficient quantity, due to the bulk of adult/family diet.
   - Diets low in energy & protein.

3. **Role of free radicals and aflotoxins:**

Free oxygen radicals produced in the body during various infections and the aflotoxin poisoning from food are usually buffered by protein and neutralized by antioxidants such as Vitamin A, C and E and selenium.

A child on protein & energy deficient diets in the presence of infection or aflotoxin accumulates toxic, free oxygen radicals, which in turn damage liver cells, leading to kwashiorkor.

4. Infections:

- A overcrowded and an unsanitary living conditions lead to frequent infections like diarrohoea.
- Kwashiorkar is often preceded by an episode of infection, diarrhea and respiratory infections being the most common precipitating factors.
- Repeated attacks of diarrhea are responsible for poor growth of children.
- Acute diarrhea leads to mal absorption of fat and protein.
- Infections arouse negative nitrogen balance.
- Measles is the other common infectious diseases that occurs during childhood.
- The impact of measles is more than that of other infections because of secondary complications and prolonged illness.
- During acute infections, appetite is often impaired and the food intake is reduced. Apart from low intake, dietary restriction is often imposed by the mother or family or community.
- Mal absorption of nutrient and metabolic losses during infection can also aggravate malnutrition.

5. Socio-economic factors

I. Poor economic status, faulty feeding habits due to ignorance and prejudice

II. Larger families and high birth rate

III. Superstitions and taboos concerning food are powerful social factors,

IV. Deprivation of maternal care and attention due to work pressure away from home by the mothers.

V. PEM is basically a problem of poverty

Inadequate diet

Poor environment

High incidence of infections results – in PEM

Measures to combat protein Energy Malnutrition

Treatment:

Severe cases of PEM, especially those with complications like severe infection or dehydration require intensive care and should be admitted to a hospital for treatment. Once the condition is controlled, the treatment can be continued outside the hospital. Nutrition support is the primary consideration in such cases.

Dehydration

- Patients with mild to moderate dehydration can be treated by oral or nasogastric administration of fluids.
- The oral rehydration solution ($NaCl$ 3.5 g: $NaHCO_3$ 2.5g: KCL 1.5 g and glucose 20 gm dissolved in 1 lit of water) recommended by the WHO can be safely used for correcting dehydration in PEM children.
  - This amount should be given in small quantities at frequent intervals over a period of 4-6 hours.
  - For patients with severe dehydration, intravenous fluid therapy is required to improve the circulation and expand plasma volume rapidly.
  - About 70-100 ml of fluid can be given in the first 3-4 hours.
  - As soon as urine flow is established, potassium supplements can be given orally (1-2g/kg/day).

Infections

- Diarrhoea and measles are often the immediate cause of death of PEM.
  Appropriate antibiotics therapy can be given.
- Intestinal infections such as giardiasis and ascariasis must be treated with appropriate deworming agents.

Hypothermia

Marasmic children are prone to have low body temperature. If the room is cold, the child should be properly covered with a blanket. The state of shock should be treated with intravenous injection of glucose-saline or blood transfusion.

Anaemia:

Severe anemia is dangerous as it can result in heart failure. If the haemoglobin falls below 5g/day, blood transfusion should be given.

Dietary management

- The child should be given a diet providing sufficient quantities of calories and protein in gradually increasing amounts, without provoking vomiting or diarrohoea.
- It is best to begin with a liquid formula with diluted milk.
- When this is accepted, vegetable oil can be added to increase energy content.
- Milk based formulae should be used for feeding children.
- If the child has milk intolerance, milk formulas can be substituted by buttermilk or cereal foods.
- In elder children, easily digestible solid foods like bread +milk +sugar can be given.
- A mixed cereal based diet can be given with added oil to increase energy density.

Suggested diet during convalescence

- Increasing the quantity of existing food .
- Increasing the number of meals to satisfy calorie and protein requirement.
- Addition of oil or ghee 1 to 2 tsp to increase calories without increasing bulk.
- Consumption of sugar and banana can be increased to increase calories in the diet.
- The child can be given cereal and pulse mixture in 5:1 proportion.
- If the patient can afford, milk, egg and skimmed milk can be included in the diet.
- Locally available, inexpensive and easily digestible foods should be used.

The following steps are suggested by FAO/WHO nutrition expert committee.

Health promotion

- Measures directed to pregnant and lactating women (education, distribution of supplements).

- Promotion of breast feeding.
- Development of low cost complementary foods. The child should be made to eat more food at frequent intervals.
- Measures to improve family diet.
- Nutrition education, promotion of correct feeding practices.
- Family planning and spacing of births.
- Improving family environment.

Specific protection

- The child's diet must contain protein and energy rich foods, milk, eggs, fresh fruits should be given if possible.
- Immunization schedule should be followed.
- Food fortification may help the child in meeting requirements.

Early diagnosis and treatment

- Periodic surveillance.
- Early diagnosis of any lag in growth.
- Early diagnosis and treatment of infections and diarrhea.
- Development of programmes for early rehydration of children with diarrhea.
- Development of supplementary feeding programmes during epidemics.
- Deworming of heavily infested children.

Integrated child development services (ICDS)

Isolated feeding programmes will not be effective unless efforts are made simultaneously to improve the environment and control infections.

Supplementary food is therefore integrated with other health activities like

1. Immunization
2. Treatment of minor illness
3. Growth monitoring

4. Health education
5. Supplementary feeding.

Nutrition Education

Education to improve child nutrition should stress

a. The importance of breast feeding
b. Timely introduction of supplements. Use of local available foods.
   Feeding sufficient quantity
   Maintenance of hygiene.
c. Feeding balanced diets for children

Over Nutrition & Obesity

One of the most common problems related to lifestyle today is overweight. Severe overweight or obesity is a key risk factor in the development of many chronic diseases such as heart and respiratory diseases, non-insulin-dependent diabetes mellitus or Type 2 diabetes mellitus, hypertension and some cancers, as well as early death.

Obesity and overweight are serious problems that pose a huge and growing financial burden on national resources. However, the conditions are largely preventable through sensible lifestyle changes.

Obesity:is a condition characterized by excess body fat, usually defined as weighing 20% above desirable weight.

Over weight is a condition where the body weight is 10-20 per cent greater than the mean standard weight for age, height and sex.

Causes:

Obesity is a multifactorial disease influenced by both genetic and environmental factors like social, behavioural, psychological, metabolic, cellular and molecular factors **(fig).**

1. Genetic factors:
   - Genetic base regulates species differences in body fat and sexual differences within the species.

- Genetic inheritance influences 50-70%
- If both parents are obese, chances of inheritance is 80% and with one parent obese the chance is 50%.
- β receptor in adipose tissue is causative factor

2. Age and sex:
    - It can occur at any age, in either sex as long as the person is under positive energy balance.
    - As per studies females are more prone to become obese than males
3. Eating habits:
    - Nibbling between meals
    - Fast eating with less chewing
    - Responding to external cues rather than internal hunger
    - Fond of cooking varieties of food
    - Frequent business lunches
    - Forcible consumption to prevent leftovers
    - Eating food outside more frequently, consumption of highly processed and junk foods
    - Cultural practices influencing consumption of more sweets and fats
    - Non inclusion of fruits and vegetables or eating more non vegetarian foods
    - Depression leading to overeating
    - Aggression and sophisticated marketing practices
4. Physical activity: Sedentary life, not participating in games and sports and using vehicles for commuting.
5. Stress: Excess release of endorphin, leads to self gratification, self punishment, depression anxiety
6. Endocrine factors: Hypothyroidism, hypogonodism and also stages like puberty, pregnancy and menopause
7. Trauma: Damage to hypothalamus leads to lack of regulation of appetite or satiety
8. Prosperity and civilization

LESSON-28

NUTRITIONAL DEFICIENCIES DISORDERS

VITAMIN A DEFICIENCY

Vitamin A is stored mainly in the liver as retinyl esters and these stores are depleted due to inadequate dietary intake, sometimes associated with infection. Relatively constant levels are maintained in the blood until body stores become depleted below a critical point.

Clinical and pathological effects:

The clinical effects of vitamin A deficiency that are best recognised are those affecting the eye. However vitamin A deficiency affects all mucous membranes of the body and the impact on the eye is later than that on some other organs. The effects are seen most markedly in periods of greatest need; early growth, pregnancy and lactation.

Xerophthalmia and Keratomalacia:

Xerophthalmia represents the ocular consequences of vitamin A deficiency and includes

- Night blindness (XN)
- Conjuctival xeroses (X1A)
- Bitot's spots (X1B)
- Corneal xerosis (X2)
- Ulceration (X3A)
- Necrosis/ Keratomalacia (X3b)

Night blindness is the earliest specific clinical symptom of vitamin A deficiency.

Opsin, a protein binds covalently with 11- cis- retinal to form rhodopsin or visual purple. Light exposure even at low levels bleaches rhodopsin. This sends electrochemical impulses along the optic nerve to the brain that results in vision. The vitamin A aldehyde is returned to the rods to form rhodopsin once again and thus the visual cycle is completed. Due to a lack of vitamin A, this cycle is disabled resulting in poor vision in dim light followed by night blindness. This is commonly seen among preschool children and pregnant women.

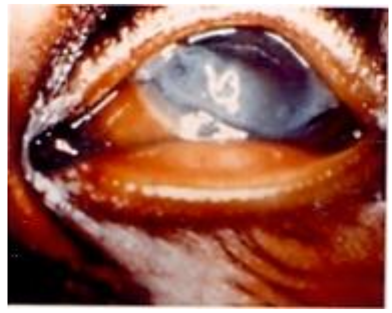
Conjunctival xerosis with Bitot's spots. Bitot's spots are grey to yellowish white foamy patches of keratinized cells present usually on the temporal conjuctival surface. They respond to high potency vitamin A and disappear within two weeks. In some cases they may persist for many months despite overcoming vitamin A deficiency. Thus they may represent past rather than present deficiency.

Corneal xerosis, ulceration and necrosis. Corneal xerophthalmia represents an acute decompensation of the corneal epithelium and is a sight threatening emergency. It responds to vitamin A therapy if treated immediately. If untreated it leads to blindness. Small ulcers in the cornea also heal with a minimum damage if treated promptly. If it is not treated it will result in meltdown of the eye with irreversible blindness in the eye.

Vitamin A Deficiency

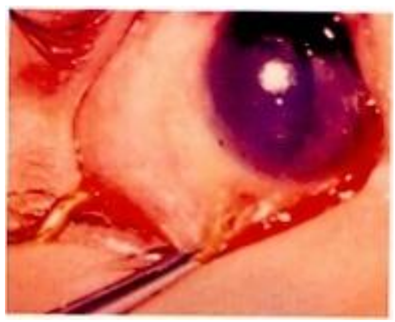
Conjunctival Xerosis

Keratomalacia



Bitot spot

Corneal xerosis



Indicators:

Traditionally, the WHO classification system for eye lesions based on increasing severity was used for establishing vitamin A deficiency. However with decreasing prevalence, a large population needs to be screened to detect the deficiency symptoms. Therefore other methods are now being used.

The relative dose response (RDR) assay

A small dose of 1.6 – 3.5 µmol of retinyl ester in oil is given as an oral dose. In response to this, the liver releases apo-RBP (Retinol binding protein). The serum retinol concentrations before and five hours after the oral dose are measured. The ratio of the difference in serum retinol concentrations between the two time points is calculated and expressed as percentage and is the RDR.

If RDR is more than 20% it indicates inadequate hepatic stores or marginal vitamin

A stores.

Conjunctival impression cytology

Impressions of epithelial cells are obtained from the conjunctival surface, stained and examined. In vitamin A deficiency, the epithelial cells of the conjunctiva become flattened and enlarged. There is a marked reduction in the mucin secreting goblet cells.

Presence of abnormal conjunctival cytology in more than 20% of children examined indicates a public health problem.

Dark adaptation thresh old

Biochemical indicators such as serum retinal and breast milk retinal are also used to assess vitamin A deficiency. A serum retinol concentration of <10 µg/dl is considered deficient, <20 µg/dl is low and ≥30µg/dl is accepted as adequate vitamin A status. Levels below 20µg/dl indicate the presence of subclinical vitamin A deficiency.

Iodine Deficiency Disorders

Iodine Deficiency Disorders refer to the wide spectrum of effects of iodine deficiency on growth and development.

Functions

Iodine functions as an integral part of the thyroid hormones which regulate the key processes in various cells of the body. The thyroid hormones are required for the normal growth and development of individual tissues, for maturation of the whole body, for energy production, oxygen consumption in cells and for maintaining the body's metabolic rate. If thyroid hormone secretion is not adequate, the basal metabolic rate is reduced and the level of activity of the individual is decreased (hypothyroidism)

The function of iodine in the body is to help synthesise thyroid hormones – thyroxin (T4) and triiodothyronine (T3). The synthesis, release and action of these hormones is regulated very finely as either excess or deficiency of these hormones will be detrimental to normal body functioning. The thyroid gland has to receive around 60µg of iodine per day to maintain an adequate supply of thyroxin.

Table 1. Spectrum of Iodine Deficiency Disorders (IDD)

1. Fetus	• Abortions • Still births • Congenital anomalies • Increased perinatal mortality

	• Increased infant mortality • Neurological cretinism: mental deficiency, deaf mutism, spastic diplegia • Myxoedematous cretinism: mental deficiency dwarfism, hypothyroidism. • Psychomotor defects
2. Neonate	• Neonatal hypothyroidism
3. Child and adolescent	• Retarded mental and physical development
4. Adult	• Goiter and its complications • Iodine induced hyperthyroidism
5. All ages	• Goiter • Hypothyroidism • Impaired mental function • Increased susceptibility to nuclear radiation.

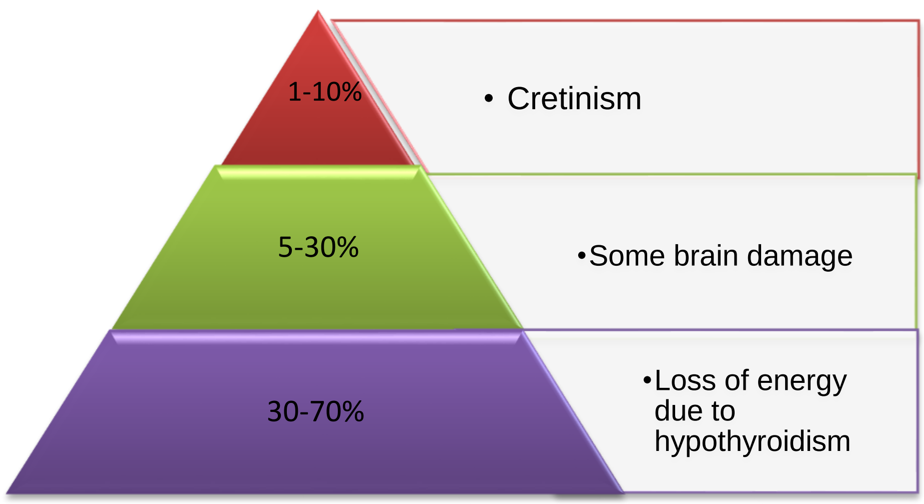
Source WHO/NHD (2001)

Grade 0	• No palpable or visible goiter
Grade 1	• A mass in the neck which is not visible but palpable, when neck is in the neutral position. It moves upwards in the neck as the subject swallows.
Grade 2	• The mass is visible and is consistent with an enlarged swelling when the neck is palpated.

Grading is also done based on the urinary excretion of iodine.

Category	Urinary Iodine level mg/dl
Mild IDD	5.0 – 9.99
Moderate IDD	2.0 – 4.99
Severe IDD	≤ 2.0

Cretinism in the visible but small component of IDD, whereas the other components, through large are generally invisible. **Cretinism**: Congenital hypothyroidism (underactivity of the thyroid gland at birth), which results in growth retardation, developmental delay, and other abnormal features. **Cretinism** can be due to deficiency of iodine in the mother's diet during pregnancy.



GOITER – GRADE 1 **GRADE - 2**

Anemia

Iron deficiency anemia is the most prevalent micro nutrient deficiency in the world. It affects more than 2000 million people in both developing and developed countries. Young children and pregnant women are the most affected group with a global prevalence of 40% and 50% respectively. Indian studies show over 65% prevalence among preschool children (Seshadri, 1994). Anemia is a public health problem in India with up to 70% of pregnant women being anemic. Nutritional anemia is most commonly caused by a deficiency of iron.

Causes

Anemia is caused by several factors that often occur together. The principal causes are –

- Negative iron balance due to inadequate dietary intake.
- Low dietary bioavailability.
- Iron loss from the body

During periods of rapid growth as in infancy, early childhood, adolescence and pregnancy, the blood volume expands and extra iron is required to maintain the concentration of blood components like hemoglobin. When the requirements are not met, anemia could occur.

Foods which supply	
Heme iron	**Non heme iron**
Liver	• Green leafy vegetables
Mutton	• Rice flakes
Fish	• Gingelly seeds
Crab	• Soybean
Prawns	• Bengal gram roasted • Dates (dried) • Bajra

The quality of iron supplied to the body – heme and non heme iron, the presence of iron absorption inhibitors and promoters – also affect the iron made available to the body.

Iron loss mainly occurs during menstruation, iron transfer to the fetus during pregnancy, blood loss during child birth, helminth infestation and malaria. It can also occur in accidental hemorrhages, and in bleeding ulcers and hemorrhoids.

Consequences of iron deficiency anemia

Pregnancy outcome

Anemia during pregnancy is associated with an increased risk to the fetus and the mother. The incidence of low birth weight, premature births and perinatal mortality is higher when the mother is even slightly anemic. Anemia is also a cause of maternal deaths. Changes in neurotransmitter levels of fetal brain are seen if mother is anemic.

Mental and motor development

Anemia, even mild anemia, affects the psychomotor and cognitive function of infants. Iron deficiency anemia at a critical period of brain growth may produce irreversible abnormalities. Lack of sufficient iron can affect attention, concentration and memory among school aged children.

Effect on growth

Anemic children have a poor growth status as indicated by their weight and height. During adolescence iron deficiency slows down the tempo of growth and the 'catch up' growth may not be optimum. Low iron stores in girls may contribute to a delayed age at menarche.

Clinical Features

- The structure and function of epithelial cells is affected by iron deficiency anemia.
- The tongue, mouth, stomach and nails are affected. The skin becomes pale and the inside of lower eyelid is also pale Finger nails became thin and flat and koilonychia develops (spoon shaped nails). Achlorhydria is also seen.
- There is atrophy of the lingual papillae and the tongue look smooth and waxy. Angular stomatitis and dysphagia may be present.

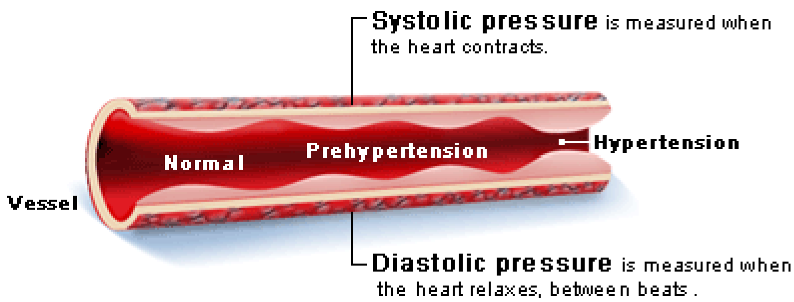
Lassitude, fatigue, breathlessness on exertion, palpitations, dizziness, headache, insomnia are some common features

Hypertension

Definition

Hypertension or **high blood pressure** is a condition in which the blood pressure in the arteries is chronically elevated. With every heart beat, the heart pumps blood through the arteries to the rest of the body. Blood pressure is the force of blood that is pushing up against the walls of the blood vessels. If the pressure is too high, the heart has to work harder to pump, and this could lead to organ damage and several illnesses such as heart attack, stroke, heart failure, aneurysm or renal failure.

WHO defines hypertension as a condition in which systolic pressure exceeds 160 mm Hg and diastolic pressure exceeds 95 mm Hg. With diastolic pressures of 100 or more therapy should be initiated with drugs as well as diet.



The normal level for blood pressure is below 110/70, where 110 represents the systolic measurement (peak pressure in the arteries) and 70 represents the diastolic measurement (minimum pressure in the arteries). Blood pressure between 110/70 and 140/90 is called prehypertension (to denote increased risk of hypertension), and a blood pressure above 140/90 is considered as hypertension.

The systolic blood pressure corresponds to the pressure in the arteries as the heart contracts and pumps blood forward into the arteries. The diastolic pressure represents the pressure in the arteries as the heart relaxes after the contraction. The diastolic pressure reflects the lowest pressure to which the arteries are exposed.

Hypertension is elevated blood pressure indicating the symptom of underlying progress of disease

Systolic pressure > 160mm Hg

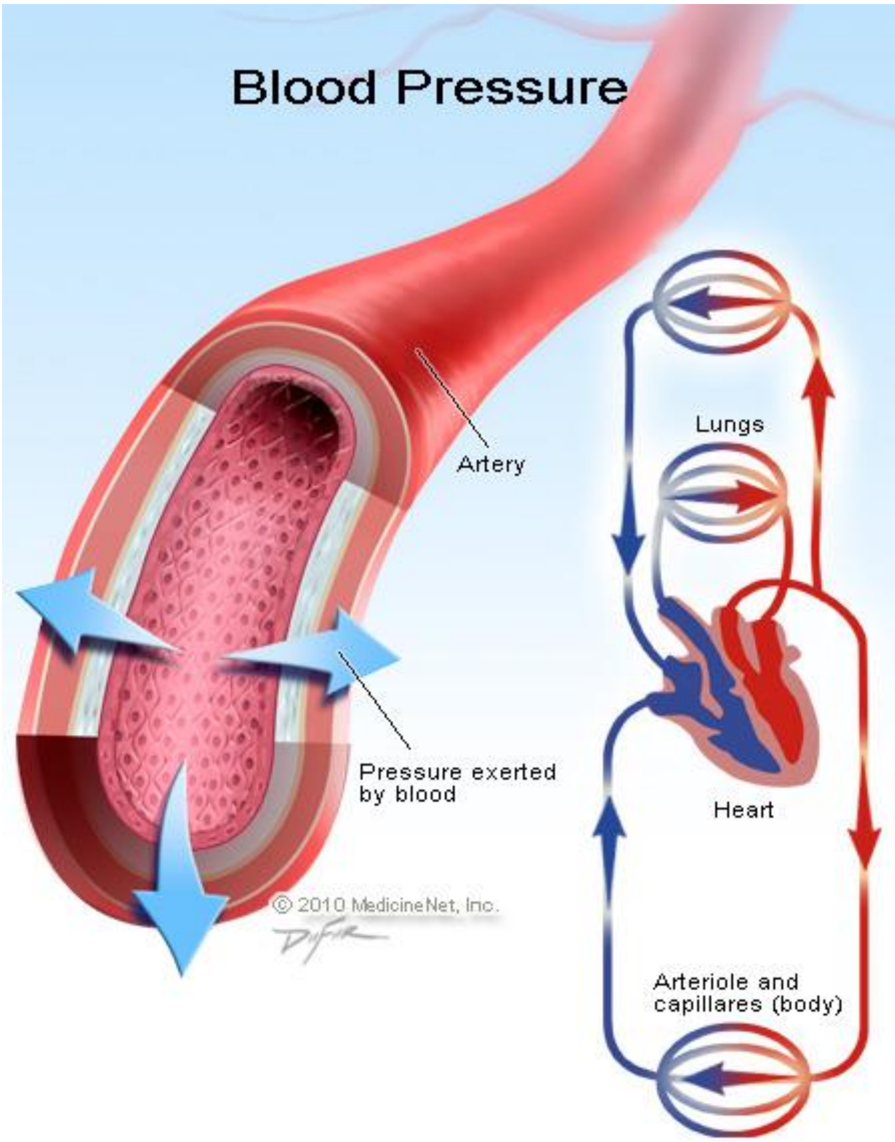
Diastolic pressure> 95mm Hg

Hypertension impairs pumping action of heart leading to damage to heart, brain and kidneys

Hypertension is increased cardiac output and increased total peripheral resistance

High Blood Pressure Overview

The heart pumps blood into the arteries with enough force to push blood to the far reaches of each organ from the top of the head to the bottom of the feet. Blood pressure can be defined as the pressure of blood on the walls of the arteries as it circulates through the body. Blood pressure is highest as its leaves the heart through the aorta and gradually decreases as it enters smaller and smaller blood vessels (arteries, arterioles, and capillaries). Blood returns in the veins leading to the heart, aided by gravity and muscle contraction.



Causes

- Diseases of CVD, pituitary gland and ovaries
- Renal-glomerulonephritis, poly nephritis, polycystic renal disease
- Tumors of brain or adrenal gland
- Hyperthyroidism
- Predisposing factors such as heredity, stress, obesity, smoking and high viscocity of blood

Types:

When the cause of hypertension is unknown, it is called essential hypertension.

Mild hypertension Diastolic pressure is 90 to 104 mm Hg. Treatment is based on weight loss, sodium restriction and behavioural techniques.

Moderate hypertension Diastolic pressure is 105 to 119 mm Hg in moderate hypertension. Nutritional therapy is supported by drugs such as blockers.

Severe hypertension Diastolic pressure is 120 to 130 mm Hg and above. Apart from giving treatment for moderate hypertension peripheral vasodilators are given. Diet therapy revolves around potassium replacement in the use of drugs and nutritional support for weight management and sodium modification.

Symptoms:

Headache, dizziness, impaired vision, failing memory, shortness of breath, pain over heart, GI disturbance

Introduction

Diabetes Mellitus is a metabolic disorder which has become very common in recent years. Because of its high prevalence, India has been described as the 'Diabetic Capital'. Its occurrence is closely linked to lifestyle and it is not as benign as people imagine it to be.

Under normal circumstances, food is consumed and digested to give glucose, amino acids and fatty acids which enter the blood stream. The glucose level in the blood rises after a meal and triggers the pancreas to the hormone insulin and release it into the bloodstream. Glucose is carried to the target cells and enters the cell with the help of insulin which is then utilized by the cell to give it energy thus the levels of glucose in blood decreases.

Diabetes mellitus is a disorder in which blood sugar (glucose) levels are abnormally high because the body does not produce enough insulin to meet its needs.

Mechanism

Raise in glucose concentration in blood

↓

Alteration in metabolism of carbohydrate, fat and protein

↓

Failure in formation of insulin or action (bound to protein)

↓

Decreased number of β cells of islets of langerhans

↓

Decreased stimulus of islets tissue

↓

Decreased Insulin

↓

Increased blood glucose level

Diabetes mellitus is associated with excessive "glycosuria", diabetes insipidus in which the excessive urine without sugar is caused by either kidney (nephrogenic DI) or pituitary gland (central DI) damage.

Lack of Insulin

Decreased anabolism

Increased secretion of glucagon, cortisol growth hormone and catecholamines

Increased catabolism

Fatigue ← Hyperglycaemia

wasting

↑ Glycogenolysis

↑ Gluconeogenesis →

Vulvitis ← Glycosuria

↑Lipolysis → Loss of weight

Polyuria ← Osmotic

Hyperketonaemia

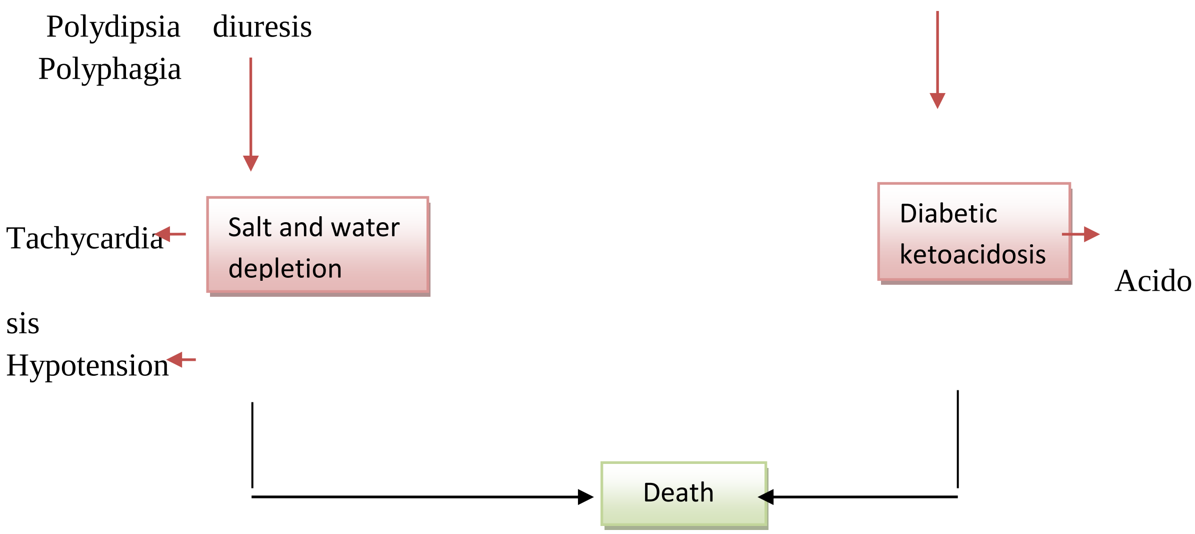


Fig. Pathophysiological basis of the symptoms and signs of untreated or uncontrolled diabetes mellitus

Source:Based on Edwards, C.R.W. lan A.D. Bouchier et al, 1995, Davidson's principles and practice of medicine, Churchill Livingstone**,** Edinburgh.

Classification:

Type I diabetes mellitus (IDDM)

- Type I diabetes affects children or adults, was traditionally termed "Juvenile diabetes" **(fig)**
- Occurs due to loss of insulin-producing beta cells of the islets of Langerhans in the pancreas, leading to a deficiency of insulin **(fig).**
- Immune-mediated or idiopathic. The majority of type I diabetes is of the immune-mediated variety, where beta cell loss is a T-cell mediated autoimmune attack.
- Most affected people are otherwise healthy with weight during onset of diabetes.
- Sensitivity and responsiveness to insulin are usually normal in the early stages
- Later the child becomes underweight and develops acidosis

Type II diabetes mellitus (NIDDM)

- Adult onset diabetes occurs due to obesity
- Milder or more stable

- Caused due to insulin resistance or reduced insulin sensitivity
- Also due to reduced insulin secretion
- The defective responsiveness of body tissues to insulin by the insulin receptor in cell membranes **(fig).**

Malnutrition Related Diabetes Mellitus (MRDM)

- Seen in young people (15-30 yrs) of tropical countries
- Pancreas fails to produce adequate amount of insulin
- Do not develop ketoacidosis

Gestational diabetes

- Gestational diabetes mellitus (GDM) resembles Type II diabetes, involving a combination of relatively inadequate insulin secretion and responsiveness
- It occurs in about 2-5% of all pregnancies and may improve or disappear after delivery.
- Gestational diabetes is fully treatable but requires careful medical supervision throughout the pregnancy
- About 20-50% of affected women develop type II diabetes later in life.
- They give birth to large babies. **(fig)**

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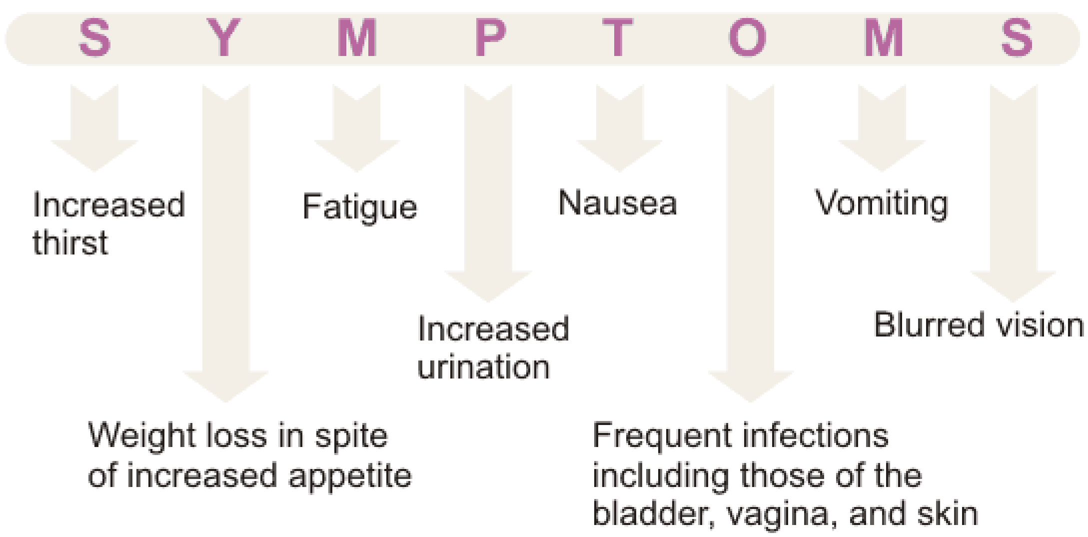
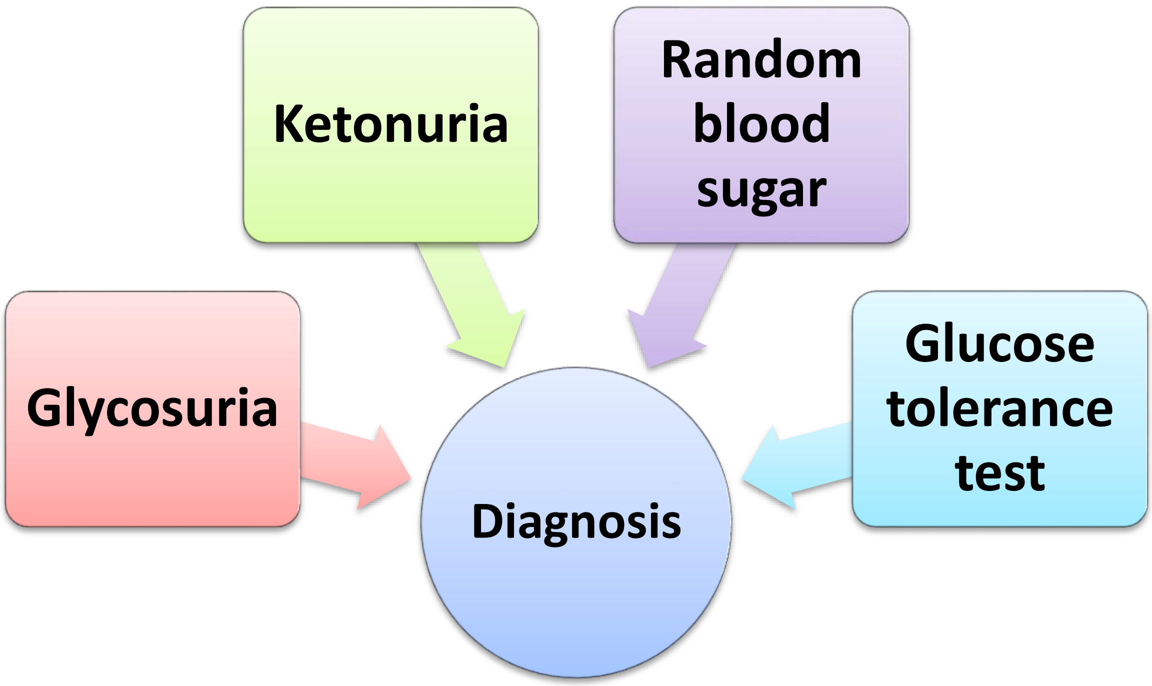
Symptoms of Diabetes



(Fig)

Diagnosis

Several tests are used in the diagnosis of diabetes.



Glycosuria

- By glucose dip-sticks method(Diastix)
- Benedicts test

Table : Interpretation of Benedict's test

Colour	Approximate Sugar in		
	Report	**Urine g%**	**Blood mg%**
Green discolouration	0 to trace	-	< 200
Green precipitate	+	0.25	200 – 250
Greenish-yellow	++	0.5	250 – 300
PRECIPITATE			
Yellowish-orange	+++	1.0	300 – 350
Precipitate			
Brick red	++++	>2.0	>350

precipitate			

Ketonuria

High amounts traced by nitro prusside reaction or by ace test tab or ketostix paper sticks.

Random blood sugar

If the fasting plasma glucose is greater than 140 mg/ dl or the random plasma glucose is greater than 200 mg/dl indicates diabetes.

Glucose tolerance test

- 75 g of glucose dissolved in 250-300 ml of water is given.
- After 2 hours of administration of glucose, blood and urine specimens are collected every 30 minutes.

National Diabetes Data Group (NDDG) in United States and the WHO expert committee on diabetes mellitus set down the criteria given in Table .

Table : Blood glucose levels

	Fasting		**2 hrs after 75g. glucose (oral)**	
	Plasma mg%	**Whole blood mg%**	**Plasma mg%**	**Whole blood mg%**
Normal	<100	<80	<140	<120
Impaired glucose tolerance	100-140	80-120	140-200	120-180
Diabetes mellitus	>140	>120	>200	>180

WHO Technical Report Series No.727, 1985.

Impaired Glucose Tolerance

Renal threshold of diabetic patient is more than 180mg of glucose/dl.

Treatment

Clinical criteria

- Relief from symptoms
- Reduction in obesity
- Prevention of acute and chronic complications
- Presence of adequate energy for normal work performance.
- In childhood diabetes to promote normal development
- During pregnancy, to deliver the normal baby without complications

Bio-chemical criteria

- Urine and blood estimates for glucose levels
- Glycosylated Hb give the trend of glucose levels of the past 2-3 months
- Maintaining normal serum lipid profile

LESSON- 29

ENERGY METABOLISM

Introduction: Human beings require enough energy to lead an active and healthy life. Energy fulfils the following functions:

(a) Maintenance of basal body functions (basal metabolism),
(b) Physical activity,
(c) Growth and development in infants and children and maintenance of pregnancy and lactation in women.

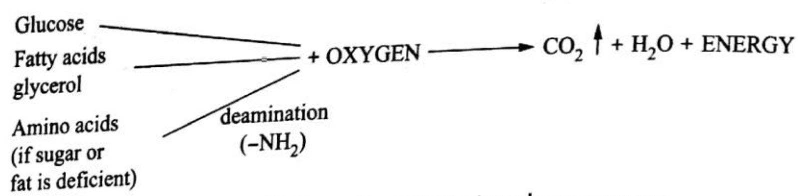


Fig. 19.1 Oxidation of nutrients to release energy

Forms of energy

Energy is defined as the ability to do work. Energy exists in several forms. The forms of energy important in nutrition are:

1. Chemical energy in food
2. Light or solar energy for synthesis of vitamin D in the skin and for photosynthesis in plants
3. Mechanical energy for movement of muscles
4. Electrical energy for functioning of the brain and nerve cells
5. Heat energy, generally produced when energy is converted from one form to another. The energy from food is finally converted into heat energy.

The various forms of energy are interconvertible.

The energy value of Foods: The energy or calorific value of foods depends on the quantity of carbohydrates, fats and proteins present in them. This can be determined by oxidizing a known weight of food in an instrument called ‘Bomb calorimeter’ and measuring the heat produced.

Energy Units: The energy value of foods can be expressed in terms of Kilo calories (Kcal) or Mega Joules (MJ). The Unit ‘Kilo Calorie’ is in use now.

Kilo Calorie: One kilogram calorie is the quantity of heat required to raise the temperature of 1kg. of water through 1^0 C. It is one thousand times the small calorie used in physics.

Mega Joule: One kilo calorie equals 4.186 kilo joules. Hence, 1,000 kilo calorie equals 40186 mega joules.

ired by a person is the sum total of basal energy needs, the take or the specific dynamic action and energy cost of physical ed for growth, for maintenance, for the innumerable processes e, for regulating body temperature, and for physical and mental need energy are broadly classified into:

ies, e.g., activities under the control of our will such as walking, und dish washing.

vities that go on irrespective of whether we want them to. der the control of our will and are vital activities on which ends such as beating of the heart, respiration, and maintaing e. Energy is first provided for these activities and is referred olism.

ody = Basal metabolic rate + Specific dynamic action + Activity

Fig. 19.5 Basal metabolism

Determination of energy requirements by direct calorimetry:

(A method to determine energy use by the body by measuring heat that emanates from the body)

The relation between energy output and oxygen consumed has been determined using the human respiration calorimeter.

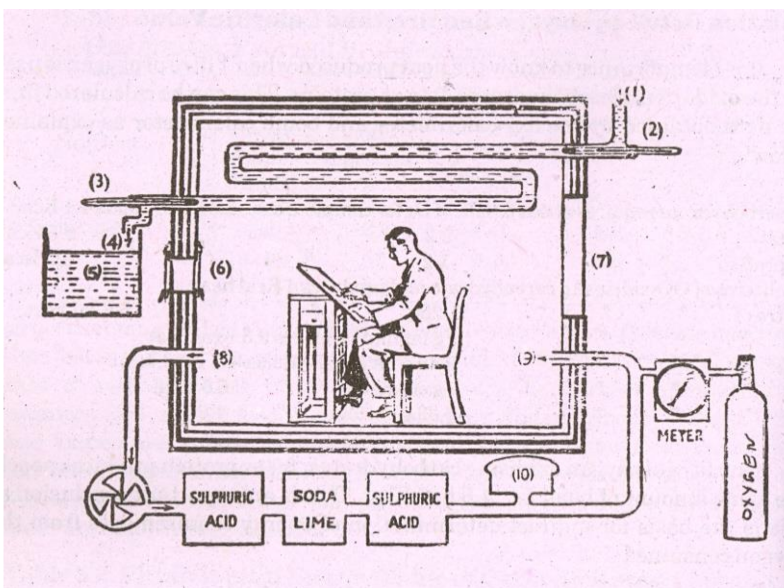
Reliable data regarding the energy output and oxygen consumed in human beings could be obtained only after Atwater –Rosa – Benedict perfected the human respiration calorimeter. This equipment consists of an air-light copper chamber insulated by wooden walls with air spaces in between. A folding bed, chair and table are provided in the chamber. A man can comfortably stay in the calorimeter for a few days and do some work such as reading, writing etc. A small opening is provided at the two ends for passing food and drink and removing the excreta. The chamber is ventilated by a current of air; the co_2 and water given off are removed by soda lime and sulphuric acid respectively. Oxygen utilized by the subject replaced by introducing known amounts of oxygen through gas meter into the chamber with the air current. From the above, the quantity of oxygen consumed and co_2 produced can be calculated. The heat produced is measured accurately by circulating a current of water through copper pipes and measuring the quantity of water that has been circulated through the chamber and also the difference between the temperature of the water entering and leaving the chamber.

Example: Adult weighing 65 kgs.

Amount of heat output in 24 hours = 2,400 KCal.

Amount of oxygen consumed in 24 hours = 500 litres.

Heat output per litre of oxygen consumed = 4.8 KCal.



Relation between Respiratory Quotient and Energy output:

The term respiratory quotient refers to the ratio between the volume of Co_2 given out and the volume of O_2consumed by the human subjects.

$$\text{Respiratory quotient (R.Q)} = \frac{\text{Vol. of } CO_2 \text{ produced}}{\text{Vol. of } O_2 \text{ consumed}}$$

When only carbohydrate is oxidized, the R.Q is 1.0 and when only fat is oxidized, the R.Q is 0.7 and when only protein is oxidized the R.Q. is 0.82. After an average meal containing 10 per cent protein, 20 per cent fat and 70 per cent carbohydrate, the R.Q. is about 0.82.

Specific Dynamic Action of Food:

Specific dynamic action (SDA) is a term used to describe the effect food has in increasing the metabolic rate above the level found when fasting. Energy is needed to digest, absorb, and metabolize the food we eat. Food intake stimulates the metabolism process leading to an increase in energy expenditure. This is known as the thermogenic effect of food or the specific dynamic effect. Proteins have maximum effect on SDA, increasing the BMR by about 30% when eaten alone, while carbohydrates and fats show smaller increases. When eaten together in a normal mixed diet, the increase is about 5–10% of basal metabolism.

Energy for physical activity

Physical activity demands about 25% to 40 % of total energy output. In choosing to be inactive or active, we determine our energy expenditure. Unlike basal metabolism, this expenditure varies widely among people. Basal metabolism uses roughly the same proportion of energy in most people (usually ± 25% to 30%).

Climbing stairs rather than riding the elevator, walking rather driving to store, and standing in a bus rather than sitting increase physical activity and hence, energy use.

Determination of energy metabolism during work:

The energy metabolism is profoundly influenced by physical work. The energy metabolism during work can be determined using one of the following equipments:

1. Douglas bag
2. Max-Planck respirometer

Basal metabolism

Definition: The energy metabolism of a subject at complete physical and mental rest and having normal body temperature and in the post –absorptive state (i.e., 12 hours after the intake of last meal) is known as Basal Metabolism.

Basal Metabolism: The minimum energy the body requires supporting itself when resting and awaking. It amounts to roughly 1 kcalorie per minute, or about 1400 kcalories per day.

Factors Affecting the Basal Metabolic Rate:

1. Body size: The B.M.R. is closely related to the body surface area. Basal metabolism is less directly related either to the height or weight of the individual.

2. Age: the B.M.R. is higher in infants and young children than in adults.

3. Females have slightly lower B.M.R. than males.

4. Body composition: The B.M.R. is directly related to the lean body mass. Persons with well developed muscles will have a higher B.M.R.than obese person whose higher body weight is due to adipose tissue.

5. Climate: In persons living in tropical climates, the B.M.R.is about 10 percent less than those living in temperate zones.

6. S.D.A. of Food: Food has a stimulating effect on B.M.R. If a person in post-absorptive state is given food, the B.M.R. has been found to increase by about 8 per cent. This is known as the Specific Dynamic Action of food.

7. Undernutrition and Starvation: prolonged undernutrition or starvation causes a reduction of about 10-20 per cent less than in B.M.R.

8. Sleep: The B.M.R. in sleep is about 5 percent less than in the basal metabolic state.
9. Fever: Fever increases the B.M.R. For every 1^0F rise in body temperature B.M.R. increases by about 7 percent. A person with high fever ($105\ ^0$ F) would have an increase of 50 per cent in the B.M.R.

10. Physical Activity: If an individual takes physical exercise about half-an –hour before the determination of B.M.R., appreciable increase in the B.M.R. is observed.

11. Fear and Nervous tension; Fear and nervous tension during the test increase the B.M.R.
12. Thyroid: Hypothyroidism decreases B.M.R. up to 30 per cent and hyperthyroidism may cause an increase in B.M.R. up to 100 percent depending on the severity of the condition.
13. Adrenaline: Injection of 1mg of adrenaline increases the B.M.R. by about 20 per cent for a few hours.
14. Anterior Pituitary: The anterior pituitary influences B.M.R. through its thyrotropic hormone, the B.M.R. being low in hypoactivity and high in hyper-activity of the glands.
15. Other Diseased Conditions: An increase in B.M.R. has been observed in splenomegly and lymphatic leukemia.

LESSON-30&31

BALACED DIET AND RDA

Balanced diet: is one which contains different types of foods in such quantities and proportions that the need for calories, proteins, minerals, vitamins and other nutrients is adequately met and a small provision is made for extra nutrients to withstand short duration of illness / leanness.

The components of a balanced diet will differ

►according to age, sex, physical activity, economic status and the physiological state viz., pregnancy, lactation etc.,

► In addition a balanced diet should also provide biochemical compounds such as dietary fiber, antioxidants and nutraceuticals which have positive health benefits.

► A balanced diet should provide around 60-70% of total calories from carbohydrates, 10-15% from protein and 20-25% of total calories from fat.

Recommended Dietary Allowances (RDA) is defined as the nutrients present in the diet which satisfies the daily requirement of all the individuals in a population (nearly 97.5%).

RDA = Requirements + Safety factor

Nutrient requirements are also influenced by sex, age and body weight. Taking all these factors into consideration, dietary intakes of nutrients are recommended for different population groups.

Summary of Recommended Dietary Allowances (RDA) for Water Soluble and Fat Soluble Vitamins for Indians - 2010 ⊛

Group	Category/Age	Body Weight (kg)	Vitamin A (µg/d) Retinol	Vitamin A (µg/d) β-carotene	Thiamine (mg/d)	Riboflavin (mg/d)	Niacin eqivalent (mg/d)	Vitamin B_6 (mg/d)	Ascorbic Acid (mg/d)	Dietary folate (µg/d)	Vitamin B_{12} (µg/d)
Men	Sedentary work	60	600	4800	1.2	1.4	16	2.0	40	200	1.0
	Moderate work				1.4	1.6	18				
	Heavy work				1.7	2.1	21				
Women	Sedentary work	55	600	4800	1.0	1.1	12	2.0	40	200	1.0
	Moderate work				1.1	1.3	14				
	Heavy work				1.4	1.7	16				
	Pregnant		800	6400	+0.2	+0.3	+2	2.5	60	500	1.2
	Lactating 0-6 m		950	7600	+0.3	+0.4	+4	2.5	80	300	1.5
	6-12 m				+0.2	+0.3	+3	2.5			
Infants	0 - 6 months	5.4	350	----	0.2	0.3	710 µg/kg	0.1	25	25	0.2
	6 –12 months	8.4		2800	0.3	0.4	650 µg/kg	0.4			
Children	1-3 years	12.9	400	3200	0.5	0.6	8	0.9	40	80	0.2-1.0
	4-6 years	18.0			0.7	0.8	11	0.9		100	
	7-9 years	25.1	600	4800	0.8	1.0	13	1.6		120	
Boys	10-12 years	34.3	600	4800	1.1	1.3	15	1.6	40	140	0.2-1.0
Girls	10-12 years	35.0			1.0	1.2	13	1.6			
Boys	13-15 years	47.6			1.4	1.6	16	2.0	40	150	0.2-1.0
Girls	13-15 years	46.6			1.2	1.4	14	2.0			
Boys	16-17 years	55.4			1.5	1.8	17	2.0	40	200	0.2-1.0
Girls	16-17 years	52.1			1.0	1.2	14	2.0			

⊛ Ref:- ICMR (Nutrient Requirements and RDA for Indians - A report of the Expert Group of the ICMR, 2010)

Summary of Recommended Dietary Allowances (RDA) for Energy, Protein, Fat and Minerals for Indians - 2010 ®

Group	Category/Age	Body Weight (kg)	Net Energy (kcal/d)	Protein (g/d)	Visible Fat (g/d)	Calcium (mg/d)	Iron (mg/d)	Zinc (mg/d)	Magnesium (mg/d)
Men	Sedentary work	60	2320	60.0	25	600	17	12	340
	Moderate work		2730		30				
	Heavy work		3490		40				
Women	Sedentary work	55	1900	55.0	20	600	21	10	310
	Moderate work		2230		25				
	Heavy work		2850		30				
	Pregnant		+350	78	30	1200	35	12	
	Lactating 0-6 m		+600	74	30	1200	21		
	6-12 m		+520	68	30				
Infants	0 - 6 months	5.4	92 kcal/kg/d*	1.16 g/kg/d*	--	500	46µg/kg/d*	---	30
	6 – 12 months	8.4	80 kcal/kg/d*	1.69 g/kg/d*	19		05	---	45
Children (Boys + Girls)	1-3 years	12.9	1060	16.7	27	600	09	5	50
	4-6 years	18.0	1350	20.1	25		13	7	70
	7-9 years	25.1	1690	29.5	30		16	8	100
Boys	10-12 years	34.3	2190	39.9	35	800	21	9	120
Girls	10-12 years	35.0	2010	40.4	35	800	27	9	160
Boys	13-15 years	47.6	2750	54.3	45	800	32	11	165
Girls	13-15 years	46.6	2330	51.9	40	800	27	11	210
Boys	16-17 years	55.4	3020	61.5	50	800	28	12	195
Girls	16-17 years	52.1	2440	55.5	35	800	26	12	235

* Requirement

® Ref:- ICMR (Nutrient Requirements and RDA for Indi
A report of the Expert Group of the ICMR, 20

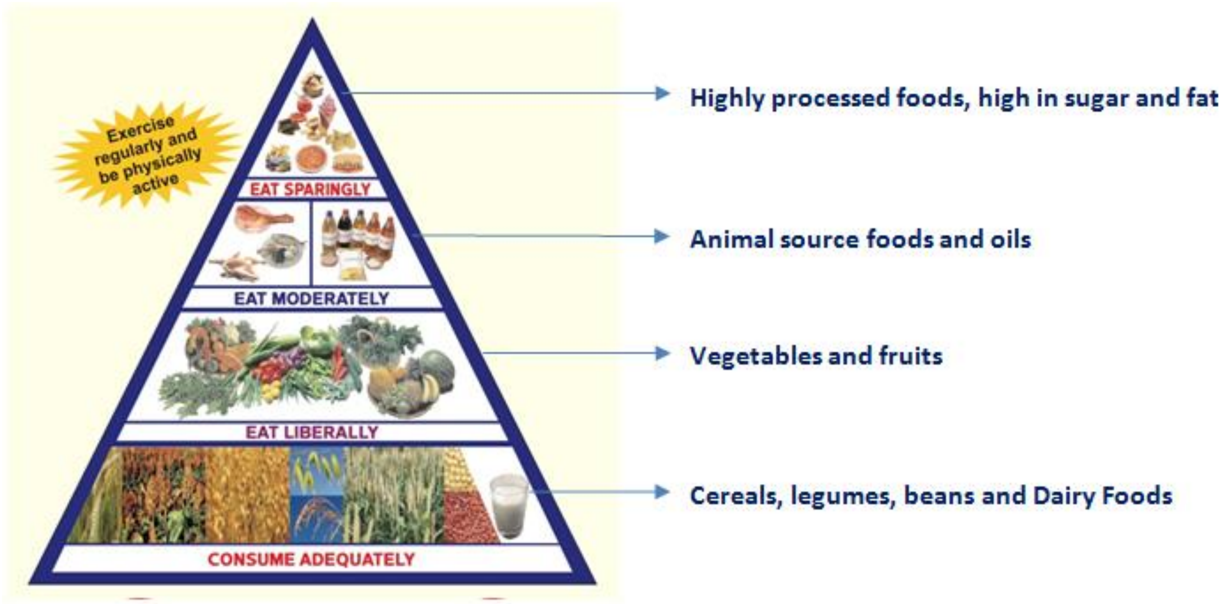
Adequate Intake (AI) is a nutrient recommendation based on observed or experimentally determined approximation of nutrient intake by a group of healthy people when sufficient scientific evidence is not available to calculate RDA.

Menu planning is the process of planning and scheduling intake of meals for general or specific individual requirements.

The Food Pyramid

The Food Pyramid is designed to make healthy eating easier. Healthy eating is about getting the correct amount of nutrients – protein, fat, carbohydrates, vitamins and minerals you need to maintain good health.

Foods that contain the same type of nutrients are grouped together on each of the shelves of the Food Pyramid. This gives you a choice of different foods from which to choose a healthy diet.



Principles of planning diets:

A) Meal planning should meet nutritional requirements:
   - A good menu is one which will not only provide adequate calories, fat and proteins but also minerals and vitamins essential for physical well being of each member of family.
   - In a balanced diet the ratio of energy distribution from carbohydrates: proteins: fats should be 7: 1: 2.
   - Diet should include basic five food groups.

B) Meal pattern must fulfil family needs:
   - A meal should cater to the needs of different members in the family
   - Meal pattern varies with age/ occupation / life style of the family members
   - The family meal must offer children enough fat and flexibility in caloric density so that their energy needs are met.

C) Meal planning should save time and energy:
   - Recipes should be simple and nutritious.
   - Labour and time saving devices can be used
   - Convenience foods can be used to save time and energy

D) Meal planning should satisfy the budget of family:
   - Cost of meals can be decreased by bulk purchasing and using seasonal fruits and vegetables.

E) Meal plan should give maximum nutrients:

- Losses of nutrients during processing / cooking should be minimised
- Sprouted grams / malted cereals / fermented foods enhance the nutritive value
- Pressure cooking can be used to conserve the nutrients

F) Consideration for individual likes and dislikes:
- Meal plan should not only meet RDA but also individual preferences
- Veg / non- veg; likes / dislikes; religion; traditions; customs.

G) Meal planning should provide variety:
- If the meals are monotonous it will not be interesting to consume.
- Create variety by introducing changes – colour/ texture/ taste etc by using different foods/ colours/ methods

H) Meals should give satiety:
- Each meal should have some amount of fat; protein; fiber to get satiety.
- Intervals between meals should be considered

I) Meal planning should be according to availability of foods:
- Menus should include locally available foods
- Wide variety in dietary pattern depends on available food supply.

Points to be considered in planning a diet:

- Variety of foods should be used in each menu.
- Minimum RDA must be met for all nutrients. For energy, total calories can be as per RDA.
- Energy derived from cereals should not be more than 75 per cent
- Whole grain cereals; parboiled rice; malted grains have higher nutritive value.
- Use two cereals in one meal
    - Ex: Rice + wheat
    - Wheat + millets
    - Rice + millets etc.
- Wheat flour should not be sieved, it reduces bran content.
- To improve cereal and pulse protein quality minimum ratio of
    - Cereal protein: pulse protein 4:1 is to be maintained
    - In terms of grains Cereal protein : pulse protein 8:1
- 2 – 3 servings of pulses should be taken every day.
- More than 1 serving green leafy vegetables can be taken, if fruits are not included. Include colourful fruits and vegetables.
- Foods rich in fiber should be included.
- It is better to serve the fruit raw without much cooking or taking juice out of it. Every day diet should contain at least 1 medium sized fruit.
- Minimum 100 ml of milk/day should be consumed. Minimum of 1-2 glasses of

milk/curd per day.

- Energy derived from foods per day
    - Fats and oils ------ 15-20% of calories
    - Jaggery/ Sugars -------- 5%
- One egg weighs around 40 gm this can be served along with cereal/ pulse to improve quality of protein. (or) one serving of poultry/ fish can be included.
    - Inclusion of salad or raita
        - Helps to meet vitamin requirements
        - Make meal attractive
        - High satiety value due to fiber
- For a low calorie diet, fried foods cannot be planned.
- 1/3rd of day's nutritional requirement --- atleast calories/ proteins should be met in lunch or dinner.
- Meal planning should be done at a time for several days.
- Usually number of meals should be 4 times. For children and patients number of meals can be more.
- Ideally, each meal should have all 5 food groups.
- For quick calculations food exchange lists can be used.
- Five servings of fruits and vegetables per day should be included to meet antioxidant requirement.
- Choose a diet low in fat; saturated fats and cholesterol.
- Combination of oils can balance n-3 and n-6 fatty acids.
- Use moderate amount of salt.
- Processed foods contain food additives. They may not be nutritionally balanced unless fortified.

Importance and modification of normal diet to therapeutic diets

Introduction:

Diet therapy is concerned with the modification of the normal diet to meet the requirements of the sick individual. The main purposes are

- To maintain good nutritional status;
- To correct deficiencies which may be present
- To provide rest to the whole body
- To improve the body's ability to metabolise the nutrients; and
- To bring about changes in body weight whenever necessary.

Diet therapy in most instances is not a remedy by itself but a measure which supplements or makes the medical or surgical treatment more effective.

Therapeutic nutrition begins with the normal diet. Advantages of using normal diet as a basis for therapeutic diets are

- It emphasizes the similarity of psychological and social needs of those who are ill and those who are well, even though there is quantitative and qualitative difference in requirements.
- Food preparation is simplified when the modified diet is based upon the family pattern and the number of items required for special preparation is reduced to minimum.
- The calculated values for the basic plan are useful in finding out the effects of addition or omission of certain foods, for example, if vegetables are restricted Vitamin A and C deficiency can occur.

Factors to be consider in planning therapeutic diets:

The alteration of the normal diet requiresan appreciation of

- The underlying disease conditions which require a change in the diet,
- The possible duration of the disease,
- The factors in the dietary which must be altered to overcome these conditions, and
- The patient's tolerance for food by mouth. In planning meals for a patient his economic status, his food preferences, his occupation and time of meals should also be considered.

The normal diet may be modified

- To provide change in consistency as in fluid and soft diets;
- To increase or decrease the energy value;
- To include greater or lesser amounts of one or more nutrients, for example, high protein, low sodium, etc;
- To increase or decrease bulk-high and low fibre diets; and
- To provide foods bland in flavour.

The planning of a therapeutic diet implies the ability to adopt the principles of normal nutrition to the various regimens for adequacy, correctness, economy and palatability. It requires recognition of the need for dietary supplements such as vitamin and mineral concentrates when the nature of the diet itself imposes severe restrictions, the patient's appetite is poor, absorption and utilization are impaired so and the diet cannot meet the needs of optimum nutrition.

Dietary history should help in planning each diet. The dietary history reveals the patient's past habits of eating with respect to dietary adequacy, likes and dislikes, meal hours, where meals are eaten, budgetary problems, ability to obtain and prepare foods. The likes and dislikes of patients are respected because food habits are deep-seated and it is not possible to change them overnight. It requires considerable encouragement and understanding on the part of the doctor-nurse-dietician team to bring about important changes in the diet. Intelligent planning of therapeutic diets necessitates consideration of food costs, the avoidance of waste, and retention of nutrient values so that the diet is economically practicable.

Types of therapeutic diets

Clear-fluid diet

- Whenever an acute illness or surgery produces a marked intolerance for food as may be evident by nausea, vomiting, anorexia, distension and diarrhoea, it is advisable to restrict the intake of food.
- In acute infections before diagnosis, in acute inflammatory conditions of the intestinal tract, following surgery of the colon or rectum when it is desirable to prevent evacuation from the bowel, etc. clear fluid diet is suggested.
- This diet is also given to relieve thirst, to supply the tissues with water, to aid in the removal of gas.

The diet is made up of clear liquids that leave no residue; it is non-gas forming, non-irritating and non-stimulating to peristaltic action.

- This diet is entirely inadequate from nutritional standpoint since it is deficient in protein, minerals, vitamins, and calories.
- It should not be continued for more than 24 to 48 hours.

- The amount of fluid is usually restricted to 30 to 60 ml per hour at first, gradually increasing the amount, as per improvement in patient's tolerance. This diet must provide 300 kcal and no protein.
- This diet can meet the requirement of fluids and some minerals and can be given with 1 to 2 hour intervals.

Full-fluid diet

- This diet bridges the gap between the clear fluid and soft diet.
- It is used following surgery, acute gastritis, acute infections and during diarrhoeal episodes.
- This diet is also suggested when milk is permitted and for patients not requiring special diet but too ill to eat solid or semisolid foods.
- In this diet foods which are liquid or which readily become liquid on reaching the stomach are given.
- This diet may be made entirely adequate and may be used over an extended time without fear of developing deficiencies, provided it is carefully planned.
- This diet is given at intervals of 2-4 hours intervals. This diet gives 1200kcal and 35g of protein.

Soft diet

- This is one of the most frequently used routine diets; many hospital patients are placed on this until a diagnosis is made.
- It bridges the gap between acute illness and convalescence. It may be used in acute infections, following surgery, and for patients who are unable to chew.
- The soft diet is made up of simple, easily digested food and contains no harsh fibre, low in fat and with mild or no seasoning.
- It is nutritionally adequate when planned on the basis of a normal diet. Patients with dental problems are given mechanically soft diet.
- It is often modified further for certain pathologic conditions as bland and low residue diets. In this diet, three meals with intermediate feedings should be given.
- This diet should provide 1500 kcal and 35-40 g of protein. Light diet should be given before regular diet.

Regular normal diet

- It is the most frequently used diet in all hospitals.
- It is used for ambulatory and bed ridden patients whose condition does not necessitate a special diet of one of the routine diets.
- Many special diets progress ultimately to a regular diet.

Table gives contents allowed for soft diet, full fluid and clear fluid diet.

Table : Contents of soft, full-fluid and clear-fluid diets

Types of food	**Foods allowed**		
	Soft diet	**Full-fluid**	**Clear-fluid**
Cereals	Refined, finely ground whole grain	Gruels, porridges kanji, ragi malt	**Barley water**
Pulses	All dals	Dal soups, dal payasam	**Dal water**
Vegetables and Fruits	Juices, pureed, cooked and mashed or baked, ripe banana	Strained juices cooked and pureed fruits and vegetables.	**Clear strained fruit juice**
Milk	Milk and milk products, cheese, fine cream	Milk and milk beverages, milk shakes, lassi	**Whey water**
Fats and oils	Butter, oil, cream, margarine	Butter, oil and cream	**-**
Meat and fish	All except pork, minced fish, poultry	-	**-**
Eggs	All except fried	Only in beverages	
Sugar and jaggery	All	Sugar, jaggery and glucose	**Sugar or glucose**

Nuts and oil seeds	None	None	**None**
Beverages	All	Tea, coffee, egg, non-carbonated beverages	**Tea, coffee (without milk) carbonated beverages, coconut water**
Soups	All	Strained	**Fat free broth**
Desserts	**Custard, kheer, pudding**	**Custard, ice cream plain gelatin**	**Plain gelatin**

- The regular hospital diet is simple in character and preparation, with ease of digestion, and calculated to afford maximum nourishment with minimum effort to the body.
- The diet is well balanced, adequate in nutritional value and attractively served to stimulate a possible poor appetite. This diet gives 1800-2000 kcal and 42-45g of protein.

LESSON -32
NEWER TRENDS IN FOOD SCIENCE & NUTRITION

Introduction

Food processing is generally regarded as a traditional industry but, advances in bio-processing and biotechnology is taking the industry at a faster rate. Biotechnology is multidisciplinary in approach involving chemical engineering, microbiology, biochemistry, genetic engineering.

Applications of Biotechnology

• Qualitative improvement in foods with nutritionally superior proteins

• Amylases and proteases are used in the manufacture of syrups and protein hydrolysates in making meat tender

• Genetic engineering can play a major role in microbial mass production

• Attempts are made to tailor made organisms to produce edible oil with higher quality and yield

Growing interest in functional foods (nutritional and medicinal) (second generation biotechnology products)

• GM crops provide new tools to improve crop productivity, reduced pesticide applications, improve micronutrient content/bioavailability of nutrients

• Available GM foods are soyabeans, maize, canola for feed, oil and processed food

• Currently in India efforts are being made for developing mustard, brinjal, potato, tomato

Basic principle of GM technology –

- DNA is transferred from a cell of one species to another unrelated species and made to express in recipient
- Used in modification of oil seeds resulting in products with high oleic acid, lauric acid, iron rich rice variety, rape seed oil with low levels of SFA's
- Golden rice is a transgenic variety with genes for the synthesis of α carotene

  Biofortification

  Biofortification – technique where varieties are bred for increased mineral and vitamin content – Iron rich rice (International Rice Research Institute) – Quality protein maize (International maize and wheat improvement center, Mexico) – High carotene sweet potato (International potato center, Peru) – High carotene cassava (International center for tropical agriculture, Colombia) – Golden rice biofortified with pro-vitamin A to overcome vitamin A deficiency

Processed and Convenience Foods

• Ready to cook (RTC), RTE, RT serve are products that require less time for preparation

• Instant rice, pulao, kichdi, halwa are being developed

• Defence Food Research Laboratory in Mysore has developed a technology by which chapatis can be stored for six months

• Extrusion Technology – is a high temperature short time process where product is pushed out by forcing through die causing minimal loss of nutrients like B complex vitamins

Retort processed foods – stored for even one year

• Energy bars – grains used may include oats, barley, wheat, corn, rice, rye, millets – Binding syrup provides sweetening and maintains water activity, provides brown colour and flavour

• Engineered foods – composed of a variety of natural/synthetic ingredients which have been modified to simulate the appearance and taste of a particular food product – non dairy coffee creamer

• Space foods – nutritious, appealing, palatable, light in weight, less in volume and possess the property of resistance to crumbling

Food Fortification

• Process whereby nutrients are added to foods (small quantities) to maintain or improve the quality of the diet of a group, or a population

• Eliminates micronutrient deficiencies

• Multinutrient fortification

further increases the cost effectiveness – iron and vitamin C

– Fluoridation of water to control dental caries

– Iodisation of salt to prevent goitre (IDD – Iodine deficiency)

– Fortification of vanaspati and milk with vitamin A&D

– DFS double fortified salt (iron and iodine)

Fortified cereals – rice is fortified with both vitamin A and iron –

Ultra rice – reconstituted vitamin A or iron fortified rice

– Wheat flour fortification with Vitamin A

– Edible oils are fortified with vitamin A

– Fortification of tea with vitamin A

– Curry powder fortification

– Sugar is fortified with vitamin A

Nutraceuticals

• Nutraceutical combines nutrition and pharmaceuticals – food extracts can be used as preventive drugs or food supplements

• Nutraceutical is defined as any substance that may be considered as food or part of food and provide medical and health benefits, including prevention and treatment of disease

• Give health benefits by acting as anti cancer agents and influencing positively on lipid blood profile

• Also have antioxidant activity and are anti inflammatory, and bone protective

Functional food: A modified food that claims to improve health or well-being by providing benefit beyond that of the traditional nutrients it contains. Functional foods may include such items as cereals, breads, beverages that are fortified with vitamins, some herbs, and nutraceuticals.

Functional foods provide **important** nutrients that can help protect against disease. Many are especially rich in antioxidants. Some **functional foods** are also high in omega-3 fatty acids, a healthy type of fat shown to reduce inflammation, boost brain **function**, and promote heart health

Examples of **functional foods** include **foods** that contain specific minerals, vitamins, fatty acids or dietary fibre, **foods** with added biologically active substances such as phytochemicals or other antioxidants and probiotics that have live beneficial cultures

Phytochemicals are chemicals of plant origin. Phytochemicals (from Greek phyto, meaning "plant") are chemicals produced by plants through primary or secondary metabolism. They generally have biological activity in the plant host and play a **role** in plant growth or defense against competitors, pathogens.

Phytonutrients identified to have nutraceutical properties include isoprenoids, polyphenolics, phytosterols, and glucosinolates

• Terpenes are found in green foods, carotenoids and limonoids (citrus peels) are subclass of terpenes

• Phytosterols – yellow vegetables, seeds of pumpkin, help in preventing tumours in prostate gland

– Flavonoids, anthocyadines, isoflavones are important subclasses of phenols

Flavonoids enhance the effectiveness of vitamin C, prevent allergies, tumors, platelet aggregation

• Anthocyanidines help in synthesis of protein, collagen while isoflavones present in beans, legumes prevent prostate and breast cancer

• Theol – sulphur containing class of phytonutrients – garlic, onion, cabbage; protect against tumours

Dietary supplements are substances you might use to add nutrients to your diet or to lower your risk of health problems, like osteoporosis or arthritis. Dietary supplements come in the form of pills, capsules, powders, gel tabs, extracts, or liquids. They might contain vitamins, minerals, fiber, amino acids, herbs or other plants, or enzymes. Sometimes, the ingredients in dietary supplements are added to foods, including drinks

Some dietary supplements can improve overall health and help manage some health conditions. For example:

- Calcium and vitamin D help keep bones strong and reduce bone loss.
- Folic acid decreases the risk of certain birth defects.
- Omega-3 fatty acids from fish oils might help some people with heart disease.
- A combination of vitamins C and E, zinc, copper, lutein, and zeaxanthin may slow down further vision loss in people with age-related macular degeneration (AMD).

Probiotics are live bacteria and yeasts that are good for you, especially your digestive system. We usually think of these as germs that cause diseases. But your body is full of bacteria, both good and bad. **Probiotics** are often called "good" or "helpful" bacteria because they help keep your gut healthy

Sports nutrition is different from normal nutrition because with sports nutrition, the athletes require more nutrients to keep their energy up during their various activities. Athletes perform strenuous activities, that is why more nutrients are needed to keep them running.

Benefits of sports nutrition

- Enables you to train longer and harder
- Delays the onset of fatigue

- Enhances performance
- Promotes optimal recovery and adaptation to your workouts
- Improves body composition and strength
- Enhances concentration
- Helps maintain healthy immune function
- Reduces the potential for injury

Modified foods

• Organic foods - Foods produced without artificial fertilizer /pesticides

• Animal manure and compost are used as natural fertilizer and crop rotation further enriches the soil

• Biocontrol of pests – fungi and specific insects are used to control pests

• Functional Foods – any food that has a positive health, physical performance or state of mind beyond the benefit of nutrition – Hypocholesterolemic agents such as garlic, fenugreek are functional foods as they protect from heart disease and cancer

Probiotics are live microbial food or feed supplements that benefit human and animal health by microbial balance in intestine (yogurt) – Lactobacillus, Bacillus, Enterococcus. Prebiotics promote the growth of probiotics in the form of specific substrates. – Non-digestible food ingredients that provide beneficial effects to the host by selectively stimulating the growth /activity of one or more limited number of bacteria in the colon – Include dietary fiber, honey, banana, onion, oats.