FST 362: Principles of Food Science and Nutrition

BSc Agriculture (Hons)

K. K. Wagh College of Agriculture, Nashik

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Course title: Principles of Food Science and Nutrition

Course : FST 362 **Credit: 2 (2+0)**

Semester-VI

Course Teacher: Dr. P.R. Chaudhary

Syllabus

Lecture	Topics	Weightage (%)
1-5	Concepts of Food Science (Properties of food: physical, chemical and sensory: their measurements)	15
6-10	Food composition and chemistry (water, carbohydrates, proteins, fats, vitamins, minerals, flavours, colours, miscellaneous bioactives, important reactions)	15
11-14	Food microbiology (bacteria, yeast, moulds, spoilage of fresh & processed foods, Production of fermented foods)	10
15-18	Principles and methods of food processing and preservation (use of heat, low temperature, chemicals, radiation, drying, high pressure processing, microwave processing, etc.)	10
19-21	Food and nutrition, Malnutrition (over and under nutrition), nutritional disorders	10
22-23	Energy metabolism (carbohydrate, fat, proteins)	5
24-25	Balanced/ modified diets, Menu planning	5
26-29	New trends in food science and nutrition	10
30-33	Fortification and enrichment of food	10
34-36	National programmes and role of national and international agencies in improving nutritional status of the community.	10

Suggested Readings:

1) Owen R, Fennema. 1996. Food Chemistry, 3rd Ed. Marcel Dekker, Inc., New York, USA.

2) M. Shafiur Rahman. 2007. Handbook of Food Preservation, 2nd Ed. CRC Press, Boca Raton, FL, USA.

3) James G. Brennan. 2006. Food Processing Handbook. Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany.

4) Fellows P. 2000. Food Processing Technology: Principles and Practice, 2nd Ed. CRC Press, Boca Raton, FL, USA.

5) William C. Frazier and & Dennis C. Westfoff. 1987. Food Microbiology, 4th Ed. Tata McGraw-Hill Education, New Delhi.

6) Carolyn D. Berdanier, Elaine B. Feldman and Johanna Dwyer. 2008. Handbook of Nutrition and Food, 2nd Ed. CRC Press, Boca Raton, FL, USA.

7) Sehgal, S. and Raghuvanshi, R.S. (2007) Text Book of Community Nutrition. ICAR, New Delhi.

8) Agarwal, A and Udipi, S. (2014). Text Book of Human Nutrition. Jaypee Medical Publication, Delhi.

9) Peter Zeuthen and Leif Bùgh-Sùrensen. 2003. Food Preservation Techniques. CRC Press LLC, Boca Raton, FL, USA.

10) Joshi V.K. and Ashok Pandey. 1999. Biotechnology: Food Fermentation – Microbiology, Biochemistry and Technology, Vol. II. Educational Publishers & Distributors, New Delhi.

11) George J. Banwart. 1989. Basic Food Microbiology, 2nd Ed. Chapman & Hall, New York, USA.

12) Kalia, M. and Sood, S. (2010). Food Preservation and Processing. Revised Edition, Kalyani Publishers, New Delhi.

13) Swaminathan, M. (1999. Food Science, Chemistry and Experimental Foods. 2nded. TheBanglore Printing and Publishing Co., Bangalore.

Chapter 1. Physical properties of Food

Physical attributes of foods consist of size, shape, volume, density, and porosity, surface area etc.

1. SIZE: Size is an important physical attribute of foods used in screening solids to separate foreign materials, grading of fruits and vegetables, and evaluating the quality of food materials. Size can determine the loss of products during processing and the final product yields. Size can be measured in three dimensions such as volume in the real world. However, it is usually reduced to one or two dimensional measurements. Size features include weight, volume, diameter, area, surface area, perimeter, length, skeleton length and width. Particle sizes are expressed in different units depending on the size range involved. Coarse particles are measured in millimeters, fine particles in terms of screen size, and very fine particles in micrometers or nanometers.

2. SHAPE: Shape is generally referred to the profile or physical structure of objects geometrically. Shape is also important in heat and mass transfer calculations, screening solids to separate foreign materials, grading of fruits and vegetables, and evaluating the quality of food materials. Shape affects the grade given to fresh fruit. To make the highest grade a fruit or vegetable must have the commonly recognized expected shape of that particular fruit/vegetable. Misshapen fruit and vegetables will be down-graded and may sell at a lower price in high volume markets. The shape of a food material is usually expressed in terms of its sphericity and aspect ratio.

3. VOLUME: Volume is defined as the amount of three-dimensional space occupied by an object, usually expressed in units that are the cubes of length units, such as cubic inches and cubic centimeters, or in units of liquid measure, such as gallons and liters. In the SI system, the unit of volume is m3. Volume is an important quality attribute in the food industry. It appeals to the eye, and is related to other quality parameters. For instance, it is inversely correlated with texture.

4. DENSITY: Density (ρ) of a material is the amount of that material occupying a certain space and is expressed in units of mass per unit volume. **The density of the object can be determined by dividing the object's mass by the measured volume.** Quality of food materials can be assessed by measuring their densities. Density data of foods are required in separation processes, such as centrifugation and sedimentation and in pneumatic and hydraulic transport of powders and particulates. **Particle density** is the mass divided by the volume of the particle alone. **Bulk density** is the mass of a group of individual particles divided by the space occupied by the entire mass, including the air space. Materials consisting of particles or grains with interstitial air spaces have different values of particle density and bulk density. Materials without internal air spaces, such as fluids and solids, have equal particle and bulk density.

5. POROSITY: Porosity is an important physical property characterizing the texture and the quality of dry and intermediate moisture foods. Porosity (ε) is defined as the volume fraction of the air or the void fraction in the sample. Porosity is the percentage of air between the particles compared to a unit volume of particles. It is expressed as:

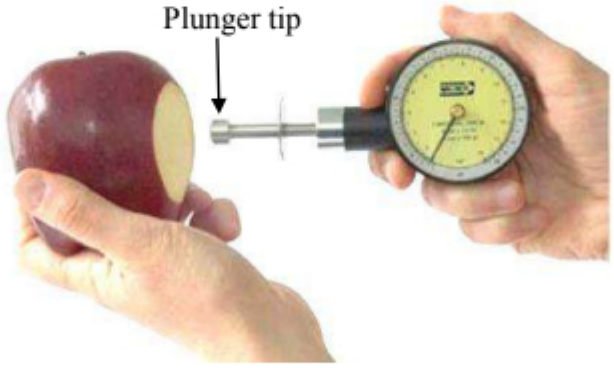
Porosity = Void volume / Total volume

Total porosity of particulate materials includes the voids within and among the particles. Porosity can be determined from the difference between bulk volume of a piece of porous material and its volume after destruction of all voids by compression, optical methods, density methods, or by using a pycnometer or porosimeter.

6. SURFACE AREA: Surface area is another important physical characteristic, which is related to size but also depends on particle shape. Surface area is difficult to measure for irregular-shaped objects and thus is often determined indirectly or computed by assuming a specific shape. Surface area is useful in estimating the amount of wax applied to fruit, amount of packaging film to wrap fruit, and rate of heating, cooling, freezing, and drying.

7. FIRMNESS: Firmness relates to the maturity of many agricultural products and is one of the measures of the quality of fruit and vegetables. Fruit firmness, in general, decreases as fruits become more mature and decreases rapidly as they ripen. Overripe or injured fruit is relatively soft. Making an accurate assessment of fruit firmness allows appropriate decisions to be made in regards to how your produce is treated. **Penetrometers** measure the **firmness** or hardness of fruit. The fruit Penetrometer accurately measures fruit hardness by measuring the force required to push a plunger tip (of a certain size) into fruit and vegetables.

8. SHRINKAGE: Shrinkage is the decrease in volume of the food during processing such as drying. When moisture is removed from food during drying, there is a pressure imbalance between inside and outside of the food. This generates contracting stresses leading to material shrinkage or collapse.



Fruit firmness measurement using **Penetrometer**

SIZE:

Produce can be sized according to different physical parameters, such as diameter, length, weight, volume, circumference, projected area, or any combination of these. It is easy to specify size for regular particles in terms of their major dimensions like length, width and thickness or major and minor diameter, but for irregular particles the term size must be arbitrarily specified.

- It allows the sorting of fresh market various agro produces into size groups. This is helps in assigning market and price differentials of large and small produce, to match consumer preferences and to allow pattern packing. Pattern packing provides better protection of the produce, utilizes the volume in the shipping container, owing to the higher packing density that can be achieved with commodities of homogeneous sizes in comparison to that of jumble packing.

- Size determination is mandatory for modern or on-line fruit/ vegetables/ grain/spices density sorting, for which two size-related parameters, volume and weight, are required.

- Size measurement is important for determining produce surface area. The latter is also of use for quantifying the microbial population on the surface of a foodstuff, for assessing the rates of heat, water vapor and gas transfer, or for estimating the throughput of peeling operations.

- Fruit size can provide useful information for suitable working of some internal quality (IQ) sensors.

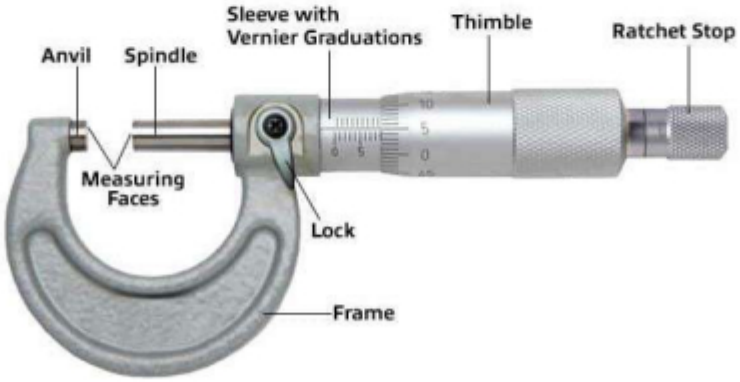
- Grading of agro produce into size groups is often necessary in the food industry, to meet the requirements of some primary and secondary processing machines, or to assign process differentials of large and small produce.

- Shape features can be measured independently or by combining size measurements. Hence, the determination of agro commodity size parameters allows simple shape sorting.

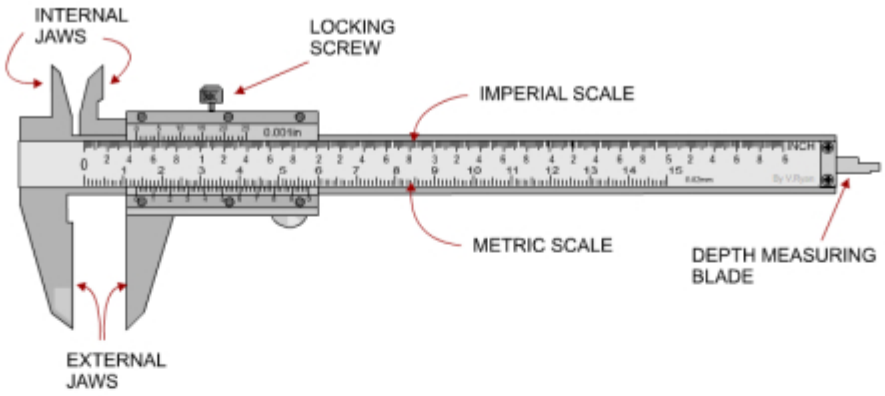
Methods of measurement of size:

Micrometer measurement:

The dimensions can be measured using a micrometer or caliper, grain shape tester. The micrometer is a simple instrument used to measure distances between surfaces. Most micrometers have a frame, anvil, spindle, sleeve, thimble, and ratchet stop. They are used to measure the outside diameters, inside diameters, the distance between parallel surfaces, and the depth of holes.



Micrometer



Vernier caliper

Vernier caliper: A Vernier caliper is an instrument that measures internal or external dimensions and distances. It allows you to take more precise measurements than you could with regular rulers. A Vernier caliper has main jaws that are used for measuring external diameter, as well as smaller jaws that are used for measuring the internal diameter of objects.

SHAPE:

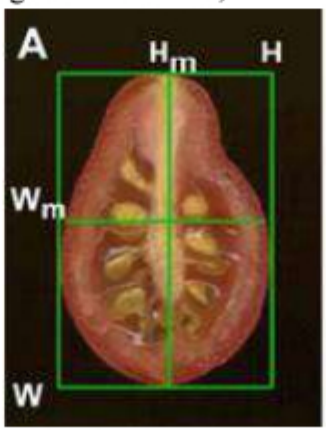
Shape describes the object in terms of a geometrical body. Shape is also important in heat and mass transfer calculations, screening solids to separate foreign materials, grading of fruits and vegetables, and evaluating the quality of food materials. The shape of a food material is usually expressed in terms of its sphericity, aspect ratio, ellipsoid ratio and slenderness ratio.

Roundness is a measure of the sharpness of the corners of the solid.

Sphericity expresses the characteristic shape of a solid object relative to that of a sphere of the same volume

Methods to measure shape

Fruit shape index I: ratio of maximum height to width, H / W.
Fruit shape index II: ratio of mid height to mid width, H m / W m.



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Some of the shapes and their descriptions are given below in table

Shape	**Description**	**Examples**
Round	Approaching Spheroid	sapota, cherry tomato, pea
Oblate	Flattened at the stem end and apex	orange, pumpkin
Oblong	Vertical diameter greater than horizontal diameter	some apple varieties, capsicum, brinjal, rice, wheat
Conic	Tapered towered the apex	ladies finger, carrot, reddish
Ovate	Egg shaped & broad at stem end	Brinjal, apple and guava.
Oblique	Axis connecting stem and apex slated	some apple varieties, tomato.
Obovate	Inverted ovate-broad at apex	Mango, papaya
Elliptical	Approaching ellipsoid	rice, wheat, pointed guard etc
Truncate	Having both hand squared or flattened	Capsicum
Unequal	One half larger than the other	Mango
Ribbed:	In cross section, sides are more or less angular	plantain, ladies finger
Regular	Horizontal section approaches a circle	orange, apple, guava etc
Irregular	Horizontal section dearth materially from a circle	mango, ladies finger, capsicum etc.

Chapter 2. 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 / Trigeminal Factors
7. Noise

These attributes are perceived through the **5 senses - sight, smell, touch, taste and sound.**

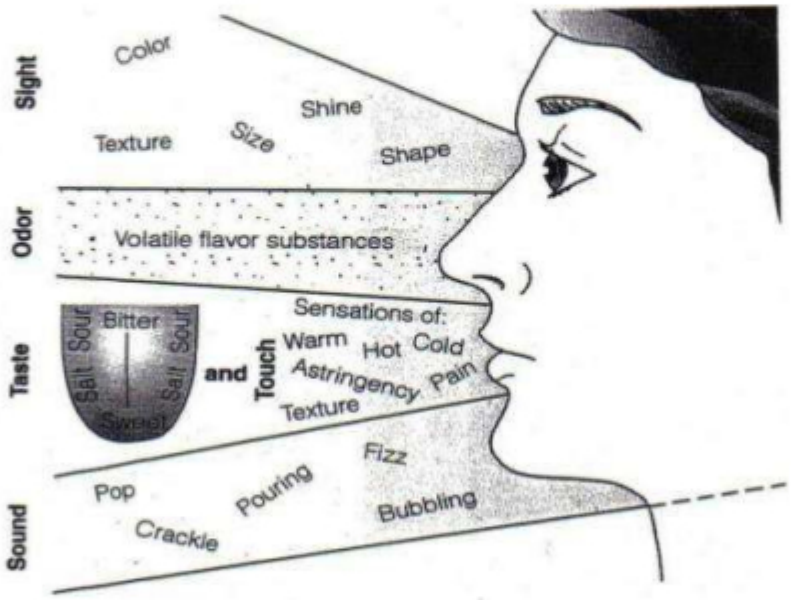


Fig: Role of five senses in sensory evaluation.

1. Appearance

The size and shape of food products, together with defects and color, are appearance factors that greatly influence initial consumer impressions. Appearance factors are also useful in sizing and grading, which ensure uniformity and facilitate the process of buying and selling. During food manufacture, grading according to size shortens the succeeding processing operations and improves the quality of the end product. Colour and appearance aspects of products should not be

overlooked because these features may render the product acceptable / unacceptable. The appearance is an attribute which a decision is taken to purchase or consume.

a) **Color:** Color is a quality factor that greatly influences the appearance of a product. Associated with it are several desirable and undesirable changes in food, such as those occurring during ripening, storage, curing, spoilage, and so on. Deterioration of food is often accompanied by a color change.

   Color is a character of light, measurable in terms of intensity and wavelength. It is a general term for all sensations arising from the activity of the human eye. When light reaches the retina it sensitizes the nerve mechanisms.

   The physical tests commonly used for color measurement are the spectrophotometric and the Munsell systems. The Munsell system a tri-stimulus system in which color is specified by three attributes; **hue, chroma, and value**.

b) **Size and shape**: Length, thickness, width, particle size, geometric shape (square, circular, etc.), distribution of pieces, e.g., of vegetables, pasta, prepared foods, etc.; size and shape are indications of quality of products.

c) **Surface texture:** The dullness or shininess of a surface, the roughness, evenness; surface characteristics i.e wet, dry, soft, hard, crisp, tough are indicators of quality.

d) **Clarity:** The haze or opacity of transparent liquids or solids, the presence or absence of particles of visible size are important indicators of quality.

2. Flavour

Definition Flavour: Flavour is the sensory impression of food or other substances, and is determined primarily by the chemical senses of taste and smell in the mouth. Flavor does not include appearance and texture.

Food flavours are classified into three categories

i. **Natural flavor** - Herbs, spices, condiments, fruits, vegetables

ii. **Processed flavor** – Caramelized, Roasted, Fermented, Toasted, Baked

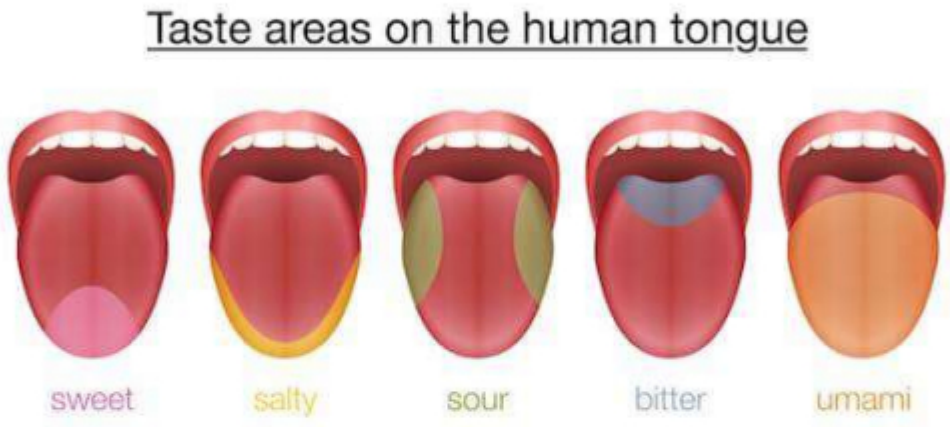
iii. **Added flavor** –

- a. Natural Extracted Flavour
  - i. Essential Oil
  - ii. Essence
  - iii. Extracts
- b. Synthetic Flavour
  - i. Fruit Flavour
  - ii. Savoury Flavour

3. Taste / Gustation

Definition: Taste is defined as gustatory perceptions (salty, sweet, sour, bitter, umami) caused by soluble substances in the mouth.

Each taste bud contains 50 to 100 taste receptor cells. The sensation of taste includes five established basic tastes: sweetness, sourness, saltiness, bitterness, and savoriness (also known as savory or umami). **Umami** is best described as a savory or "meaty" **flavor**. The word "**umami**" is Japanese and means "a pleasant savory **taste**." It is characteristic flavor of broths and cooked meats and added monosodium glutamate (MSG)



4. Odour/ Aroma/ Fragrance

This sense plays paramount role in evaluation of quality of food products. The role of olfactory perception is greater in overall flavour than the taste. Food products are smelled for aroma perception immediately after the opening of closure/ package and earlier than the taste.

The odor of a product is detected when its volatiles enter the nasal passage and are perceived by the olfactory system. We talk of odor when the volatiles are sniffed through the nose (voluntarily or otherwise). Aroma is the odor of a food product, and fragrance is the odor of a perfume or cosmetic.

Aromatics, are the volatiles perceived by the olfactory system from a substance in the mouth. The amount of volatiles that escape from a product is affected by the temperature and by the nature of the compounds.

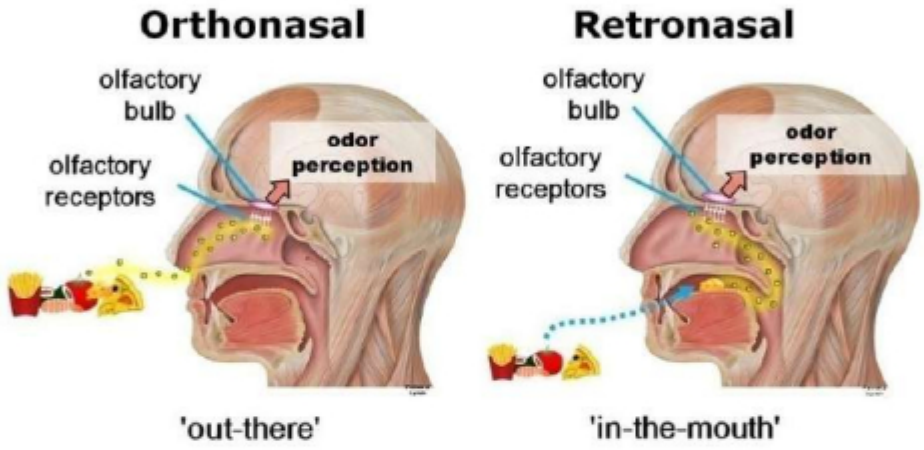
Volatility is also influenced by the condition of a surface: at a given temperature, more volatiles escape from a soft, porous, and humid surface than from a hard, smooth, and dry one.

Many odors are released only when an enzymatic reaction takes place at a freshly cut surface (e.g., the smell of an onion). Odorous molecules must be transmitted by a gas, which can be the

atmosphere, water vapor, or an industrial gas, and the intensity of the perceived odor is determined by the proportion of such gas which comes into contact with the observer's olfactory receptors .

Definition Aromatics: The term "aromatics" is used to indicate those volatile constituents that originate from food in the mouth and are perceived by the olfactory system via the posterior nares.

- **Retronasal olfaction** is the perception of odors emanating from the oral cavity during eating and drinking, as opposed to
- **Orthonasal olfaction**, is perception of odors during sniffing. The **retronasal olfactory** pathway, which contributes to the flavor of foods or drinks, is commonly associated with the sense of taste.



5. Consistency and Texture

Tactual and mouth feel play an important role in examining the body and texture characteristics. The pressure between the teeth and jaws determine the hardness, chewiness and gumminess. The fingertips and ball of the thump help in determining other textural attributes, notably stickiness, elasticity/ sponginess and brittleness

The other set of attributes to be considered are those perceived by sensors in the mouth

- Viscosity (for homogeneous Newtonian liquids)
- Consistency (for non-Newtonian or heterogeneous liquids and semisolids)
- Texture (for solids or semisolids)

Viscosity refers to the rate of flow of liquids under some force, such as gravity.

Food texture is defined as those properties of a food that are sensed by touch in the mouth (tongue, jaw, lips) and with the hands. It is sensory indicator of the structure of food products.We use many words to describe food texture—foods can be soft or hard, mushy or crunchy, or smooth

or lumpy. Texture is important to the enjoyment and acceptability of foods. Ex. Would you enjoy a mushy apple or soggy toast?

Tactile feel properties, measured as geometrical particles (grainy, gritty, crystalline, flaky) or moisture properties (wetness, oiliness, moistness, dryness) by the tactile nerves in the surface of the skin of the hand, lips, or tongue.

6. Chemical / Trigeminal senses

Definition: The trigeminal system is a chemical sense which allows the perception of chemosensory stimulus such as burn, heat, cold, pungency, spiciness etc

The "trigeminal senses", which detect chemical irritants in the mouth and throat, may also occasionally determine flavor. Chemical irritants such as ammonia, ginger, horseradish, onion, chili peppers, menthol, etc. stimulate the trigeminal nerve ends, causing perceptions of burn, heat, cold, pungency, etc. in the mucosa of the eyes, nose, and mouth.

7. Noise

The noise produced during mastication (chewing) of foods is a minor but not negligible sensory attribute. It is common to measure the pitch, loudness, and persistence of sounds produced by foods. The pitch and loudness of the sound contribute to the overall sensory impression. Differences in pitch of some rupturing foods (crispy, crunchy, brittle) provide sensory input, which we use in the assessment of freshness/staleness.

Common Noise Characteristics of Foods,

Pitch: frequency of sound, Crispy, Crunchy, Squeak

Loudness: intensity of sound

Persistence: endurance of sound over time, Perceived sounds (pitch, loudness, persistence) and auditory measurement

6. Other Properties

The Components of Texture

- ***Hardness:*** force to attain a given deformation **:** Firmness(compression) Hardness (bite)
- ***Cohesiveness:*** degree to which sample deforms (rather than ruptures)
- ***Adhesiveness:*** force required to remove sample from a given surface Sticky (tooth/palate)
- ***Denseness:*** compactness of cross-section Dense/heavy Airy/puffy/light
- ***Springiness:*** rate of return to original shape after some deformation Springy/rubbery Cushy

Geometrical Properties: perception of particles (size, shape, orientation) measured by tactile means

- ***Smoothness:*** absence of all particles
- ***Gritty:*** small, hard particles
- ***Grainy:*** small particles
- ***Chalky/powdery:*** fine particles (film)
- ***Fibrous:*** long, stringy particles (fuzzy fabric)
- ***Lumpy/bumpy:*** large, even pieces or protrusions

Moisture Properties: perception of water, oil, fat, measured by tactile means

- ***Moistness:*** amount of wetness/oiliness present
- ***Moisture release:*** amount of wetness/oiliness exuded/ Juicy
- ***Oily:*** amount of liquid fat
- ***Greasy:*** amount of solid fat

SENSORY EVALUATION OF FOOD

Definition: Sensory evaluation has been defined as a scientific method to **evoke, measure, analyze and interpret** those responses to products as perceived through the senses of sight, smell, touch, taste and hearing (Stone and Sidel, 1995).

In food and beverage companies, sensory evaluation of products can provide an understanding of the key sensory properties that drive consumer acceptability.

Tests for sensory evaluation are of three types:

1. **Discrimination / Difference testing** - This is the sensory testing designed to determine whether detectable differences or similarities exist between the products.

i. **Triangle test** – Panelist is presented with one different and two alike (same) samples. The panelist is instructed to identify the odd sample and record his answer.
ii. **Duo – Trio test** - Panelists are presented with a reference samples, and then two test samples; one sample is the same as the reference, and the other is the sample to be tested. Panelists are asked to identify the sample that is the same as the reference sample.
iii. **Paired comparison test** – Panelists are given two samples and asked which one is preferred. It is the difference test in which a specific characteristic (ex sweetness) is to be

evaluated in two samples, and the sample with the greater level of that characteristic is to be identified.

2. **Preference / Affective testing** - It is the sensory testing to determine the acceptability or preference or liking between products.

i. **Rank order:** Preference or difference test in which all samples are ranked in order of intensity of a specific characteristic (ex sweetness)

ii. **Hedonic Test:** The hedonic scale may be used to determine degree of acceptability of one or more products. This scale is a category-type scale with an odd number (five to nine) categories ranging from "dislike extremely" to "like extremely." A neutral midpoint (neither like nor dislike) is included. Consumers rate the product on the scale based on their response.

3. **Descriptive testing** - It is the testing which provides information on selected characteristics of food samples and determining the sensory profile of the products. It uses of key or descriptive words in sensory evaluation to characterize food samples.

Chapter 3. Chemical Properties of Food

Basic food chemistry deals with the three primary components in food: carbohydrates, lipids and proteins and other components water, vitamins, minerals, flavours, colours, miscellaneous bioactives

The foods which we use daily include rice, wheat, dal, vegetables, fruits, milk, eggs, fish, meat, sugar, butter, oils, etc. These different foods are made up of a number of chemical components called nutrients. These are classified according to their chemical composition. Each nutrient class has its own function, but the various nutrients must act in unison for effective action. The nutrients found in foods are — carbohydrates, proteins, fats, minerals, vitamins and water. Fibre is also an essential component of our diet. **The functions of nutrients are given below**.

1. **Water:** We get water in foods we eat and a major part from the water we drink as such and as beverages. Water is an essential part of our body structure and it accounts for about **60 per cent of our body weight.** Water is essential for the utilisation of food material in the body and also for elimination of food waste. It is a regulator of body processes such as maintenance of body temperature.
2. **Carbohydrates:** Starch found in cereals and sugar in sugarcane and fruits are examples of carbohydrates in foods. The chief function of carbohydrates is to provide energy needed by our body. Those not used immediately for this purpose are stored as glycogen or converted to fat and stored, to be mobilised for energy supply when needed.
3. **Proteins:** Casein from milk, albumin in egg, globulins in legumes and gluten in wheat, are examples of proteins occurring in foods. The main function of protein is the building of new tissues and maintaining and repair of those already built. Synthesis of regulatory and protective substances such as enzymes, hormones and antibodies is also a function of food proteins. About **10 per cent of the total energy is supplied by proteins** in the diet. Protein, when taken in excess of the body's need, is converted to carbohydrates and fats and is stored in the body.
4. **Fats:** Oils found in seeds, butter from milk, and lard from meat, are examples of fats found in foods. Fats are concentrated sources of energy, carriers of fat soluble vitamins and a source of essential fatty acids. If excess fats are taken in the diet, these are stored as fat reserves in the body. Energy taken in excess of body needs, is stored as fat in the body.
5. **Minerals:** The minerals calcium, phosphorus, iron, iodine, sodium, potassium and others are found in various foods in combination with organic and inorganic compounds. Minerals are necessary for body-building, for building of bones, teeth and structural parts of soft tissues. They also play a role in regulation of processes in the body, e.g., muscle contraction, clotting of blood, nerve stimuli, etc.
6. **Vitamins:** Fat-soluble vitamins A, D, E and K and also water-soluble vitamins C and B group are found in foods. These are needed for growth, normal function of the body and normal body processes.

1. Water

Introduction

Approximately **55 to 70 %** of the total body weight is made up of water. The percentage of water tends to decrease as a person gets older. Thus infants and children have a much higher content of water than adults. Fat individuals have less water than lean ones. Water is an essential nutrient next only in importance to oxygen. Deprivation of water even for a few days can lead to death.

- **Water in Food – Fruits and vegetables**

1) Most of the fruits and vegetables contain 70-80% moisture while some vegetables like leafy vegetables and melons contain almost 92-95% moisture. The tubers crops like cassava, yam and corms contain less moisture (around 50%) and are more starchy.
2) Moisture plays an important role in fruits and vegetables because many of the nutrients exist in soluble state in them.
3) The higher moisture content makes the fruits, vegetables and flowers perishable as it is easily vulnerable to attack by microorganisms.
4) Further moisture is lost during the biological activity of these commodities which deteriorates its quality in terms of freshness.
5) Therefore, retention of the moisture or prevention of loss of moisture is one of the important considerations in planning a storage technique or strategy for extension of shelf life.
6) The actual water content is dependent on the availability of water to the tissue at the time of harvest. Water content of produce will vary during the day if there are fluctuations in temperature. For most produce, it is desirable to harvest when the maximum possible water content is present as these results in a crisp texture.
7) Examples of moisture content of some of fruits and vegetables
   - 95% - cucumber, lettuce, melons
   - >80% - many Fruits & Vegetables
   - 50% - starch tubers and seeds like –yam, cassava and corn
8) Water is an essential constituent in which organisms' life processes occur. In food, water presents predominantly as an intracellular or extracellular component in plant and animal food products.
9) Interaction of water with other food constituents results in controlling many chemical and physical reactions which significantly contributes to shelf life and quality values of food products.
10) For instance, removal of water from food by physical or chemical methods such as binding it with salt or sugar inhibits chemical and enzymatic reactions produced by microorganisms, resulting in shelf life improvement of food products.
11) On the other hand physical interaction of water with macromolecules may contribute to the physical appearance of food
12) Water (moisture) is the predominant constituent in many food products. As a medium, water supports chemical reactions, and it is a direct reactant in hydrolytic processes. Therefore, removal of water from food, or binding it by increasing the concentration of common salt or sugar retards many reactions and inhibits the growth of microorganisms, thus improving the

shelf life of a number of foods. Through physical interaction with proteins, polysaccharides, lipids, and salts, water contributes significantly to the texture of food.

No	Product	Moisture content % (g/100g)
1	Fruits	79-90 %
2	Vegetables	70-90 %
3	Milk	87 %
4	Bread	35 %
5	Honey	20 %
6	Butter	16-18 %
7	Milk powder	4 %
8	Edible oil	0 %

Water activity (a_w)

1. Water in food which is not bound to food molecules can support the growth of bacteria, yeasts and molds (fungi). The term water activity (a_w) refers to this unbound water.
2. **Definition: The water activity (aw) represents the ratio of the water vapor pressure of the food to the water vapor pressure of pure water under the same conditions**
3. Water activity **(a_w)** influences the storability of foods. Decreased water activity retards the growth of microorganisms and slows enzyme-catalyzed reactions (particularly involving hydrolyses).
4. The storage stability of food with $\mathbf{a_w}$ between 0.2 and 0.4 is the highest. This $\mathbf{a_w}$ range obviates the need for preservatives against microbial spoilage, and food quality is unaffected by nonenzymatic browning and lipid auto-oxidation, because these reactions are essentially prevented.
5. Food products with $\mathbf{a_w}$ values between 0.6 and 0.9 are known as "intermediate moisture foods." These food products must be protected extensively against microbial spoilage. One of the options to decreasing water activity, and thus improving the shelf life of food, is to use additives with high water-binding capacities (humectants).

Type of Product	Water Activity (AW)
Fresh meat and fish	0.99
Bread	0.95
Aged Cheddar cheese	0.85
Jams and jellies	0.8
Plum pudding	0.8
Dried Fruit (prunes, fig)	0.6
Biscuits	0.3
Milk powder	0.2
Instant coffee	0.2

Functions of water in body :

1. Water serves as a building material for each cell of the body.
2. Water is a universal solvent and is able to dissolve all the products of digestion.
3. Further as it is a constituent of all body fluids, it helps in the transport of the products of digestion to the appropriate organs. For example, **blood, which contains 90 per cent water**, carries carbon dioxide to the lungs, nutrients to the cells and waste nitrogenous material and salt to the kidneys.
4. Urine which contains 97 per cent water has all the waste material dissolved in it and the body is thus able to excrete soluble waste products of metabolism.
5. Water is needed for many chemical reactions to occur in the body. For example, the breakdown of sugar to simpler substances needs the presence of water.
6. Water acts as a lubricant preventing friction between moving parts of the body.
7. The body temperature is regulated through the evaporation of water from the skin and lungs.

Sources:

1. The water we drink as such is the main source from which maximum water is obtained by the human body.
2. In addition to this, the intake of all beverages and liquid foods that contain water, contribute water to the system.
3. Certain metabolic reactions carried on inside the body also release water and this is another source of water.
4. In a water balance study it was found that of the total 2200 ml available water in the system, 1100 ml was obtained by drinking water as such, 900 ml was obtained from the diet and 200 ml obtained from the metabolic oxidation.

Health Problems

1. **Dehydration: When intake of water and other fluids is less than the body needs, dehydration occurs**. Dehydration is a serious medical problem, which needs prompt attention and remedial action. Dehydration results from excessive loss of water due to vomiting and/or diarrhoea. Infants who have a high body water content and high water requirement get dehydrated very quickly, when they suffer from diarrhoea. If the loss of water and electrolytes is not promptly made up by feeding beverages such as oral rehydration solution, coconut water, weak tea, lemon sherbet, etc., the infant may not survive.
2. **Vomitting** due to either gastrointestinal disturbances or any other cause can lead to appreciable loss of fluid from the body.
3. **Excessive perspiration** due to strenuous exercise, while playing games such as hockey, football can result in losses of many litres of water.
4. **Protracted fevers** can lead to appreciable loss of water due to perspiration. In all such instances where there is loss of water, it is important to replace the water and soluble salts lost quickly to maintain body composition.

5. **Any loss more than 10 per cent of fluid from the body can be serious**. Progressively, deprivation of water can cause poor absorption of food, delayed elimination of wastes, elevation of body temperature, failure of the circulatory system and malfunctioning of the renal system.
6. **Oedema** is accumulation of excess fluid in the tissues. It occurs when the sodium content in the extracellular fluid increases due to the inability of the kidneys to excrete sodium. Water is retained with the excess sodium, resulting in oedema.

2. Carbohydrates

Introduction

Carbohydrates make up a group of chemical compounds found in plant and animal cells. Carbohyrates are the major constituent after water, which account for 2-40% in tissues with lowest found in cucurbits and highest found in cassava. They have an empirical formula $C_nH_{2n}O_n$ or $(CH_2O)_n$ or $Cx(H_2O)y$,. Since this formula is essentially a combination of carbon and water these materials are called "hydrates of carbon or carbohydrates". Carbohydrates are the primary product of plant *photosynthesis*, and are consumed as fuel by plants and animals.

Carbohydrate Functions in Body:

1. The primary function of carbohydrates in the body is to **supply energy**. Each gramme of carbohydrate, as starch or sugar, provides **4 kcal/g**. In Indian diet about 65 to 80 % energy is provided by carbohydrates.
2. Carbohydrates act also as **reserve fuel supply in the form of glycogen**, stored in muscles and liver. The total amount of glycogen in the body is over 300g. But it must be maintained by regular intake of carbohydrates at frequent intervals, so that the breakdown of fat and protein tissue is prevented.
3. Carbohydrates serve other special functions in the body. Carbohydrates provide **chemical framework,** which combine with the nitrogen to synthesise non-essential amino acids in the body.
4. Carbohydrates and their derivatives **work as precursors** of important metabolic compounds. These include nucleic acids, the matrix of connective tissue and galactosides of nerve tissue.
5. Lactose, the milk sugar, provides galactose needed for **brain development**. It aids absorption of calcium and phosphorus, thus helping bone growth and maintenance.
6. Lactose forms lactic acid in the intestinal track due to the action of the bacteria (lactobacilli) present there. These **lactobacilli synthesise some of the B-complex vitamins**. It aids, bacteria (lactobacilli) present to suppress the activities of putrefactive bacteria and protects us from their undesirable effects.
7. Carbohydrates are an important part of some compounds, which increase our resistance to infection (immunopolysaccharides). **Ribose, a five carbon sugar, is an essential part of DNA and RNA**. Carbohydrates are a part of important compounds, which are components of nervous tissue (galactolipid), heart valve, cartilage, bone and skin (chondroitin sulfate).
8. Carbohydrates are needed for ensuring complete normal metabolism of fats, thus preventing acidosis.
9. Carbohydrates are needed to **prevent dehydration**. A low carbohydrate diet causes loss of water from tissues as also electrolytes (especially sodium and potassium) in the urine and can lead to involuntary dehydration.
10. **Dietary fibre acts like a sponge and absorbs water**. It helps smooth movement of food waste through the digestive tract and the soft, bulky stools are comfortably eliminated.

Food Sources: Carbohydrates are synthesized by plants and occur in several forms.

1. **Starch** is found in plant seeds (cereals and legumes), roots and tubers.
2. The intake of complex carbohydrate in the form of **cereals, dals and legumes**, in normal Indian dietary is sufficient.
3. Cereals, which are the staple food in the Indian dietary, contribute major part of the energy and proteins, and some minerals and vitamins.
4. Dals and legumes provide significant amounts of proteins, iron and B-vitamins, in addition to energy.
5. **Potatoes, yams, jackfruit** are good source of starch in the diet. Vegetables and fruits provide dietary fibre, minerals and vitamins.
6. **Milk** is the only animal food, which is the source of a very important sugar—**lactose**—in the diet.
7. Sugars are found in fruits; the percentage is about three in melons, ten in citrus fruits and guava and seventeen in mango. Thus fruits are an excellent snack food as they are a dilute source of quick energy and other nutrients.
8. Sugars found in plant sap or juice (sugarcane and beetroot) is extracted to give pure 100 per cent sugar. It must be used judiciously, as it provides only energy. The intake of foods high in added sugars, such as soft drinks, syrups and sweets needs to be controlled to avoid obesity.

Classification of Carbohydrates:

- **Monosaccharides**
  Monosaccharides are simple carbohydrates containing three to eight carbon atoms, but only those with five or six carbon atoms are common. Two of the most important ones in foods are the six-carbon sugars, glucose and fructose, which have the general formula $C_6H_{12}O_6$. The monosaccharides can be divided into two groups: the aldoses, which have an aldehyde group, and the ketoses, which have a ketone group. Glucose is categorized as an aldose sugar due to an aldehyde group (CHO) located on the first carbon atom of the chain, while fructose is a ketose sugar.

- **Oligosaccharides**
  Molecules containing a small number (2 to 10) of monosaccharides connected by glycosidic linkage are oligosaccharides. The reducing group of one monosaccharide can connect to one of the hydroxyl groups on another through glycosidic bond, to form disaccharides. More connections of glycosidic bonds will give rise to trisaccharides, tetrasaccharides, etc., categorized as oligosaccharides and ultimately polysaccharides.
  a) Disaccharide – $C_n(H_2O)_{n-1}$
     1. Reducing sugar – i) Lactose (milk sugar) = Glucose + Galactose
        ii)Maltose (Grain sugar) = Glucose + Glucose
     2. Non-reducing sugar – i) Sucrose (Cane Sugar) = Glucose + Fructose

  b) Trisaccharide – $C_n(H_2O)_{n-2}$: Raffinose = Fructose + Glucose + Galactose

- **Polysaccharides ($C_6H_{10}O_5)_n$**

When oligosaccharides have more than ten monosaccharides the unit is known as polysaccharide. Polysaccharides consist of monosaccharide units bound to each other by glycosidic linkages. Their complete acidic hydrolysis yields monosaccharides. Polysaccharides (**glycans**) can have only a type of sugar structural unit (**homoglycans**) or several types of sugar units (**heteroglycans**).

Polysaccharides may have a linear pattern (as in cellulose and amylose) or a branched fashion (amylopectin, glycogen, guaran) of monosaccharide unit linkage.

Unlike monosaccharides and oligosaccharides, **polysaccharides are in many cases insoluble** or at the best not readily soluble in water. They do not have sweet taste and are essentially inert. Mono and oligosaccharides and their corresponding sugar alcohols with few exceptions are sweet.

In general, starch is confined to the plastid compartments of fruit cells, where it exists as granules made up of both amylose and amylopectin molecules.

- **Reducing and non reducing sugar**

A **reducing sugar** is any sugar that is capable of acting as a reducing agent because it has a free aldehyde group or a free ketone group. **Reducing sugars** are **sugars** where the anomeric carbon has an OH group attached that can **reduce** other compounds. **Non-reducing sugars** do not have an OH group attached to the anomeric carbon so they cannot **reduce** other compounds. Maltose and lactose are **reducing sugars**, while sucrose is a **non-reducing sugar**. All monosaccharides are reducing sugars, along with some disaccharides, oligosaccharides, and polysaccharides.

Carbohydrates are naturally occurring sugars, starches and fiber in food.

- **Sugars** – Many tropical and sub-tropical fruits contain highest level of sugars. Sucrose, Glucose, and fructose are the primary sugars found in fruits. Glucose and fructose are the major sugars in all fruits and often present in similar level, while sucrose is only present in about 2/3rd of the produce. It helps in imparting colour, flavour, appearance and texture to the fruits. Flavour is fundamentally the balance between sugar and acids ratios. Sugar is the primary substrate for respiration and energy.

Produce with the highest sugar levels are mainly tropical and subtropical fruit, with grape the only temperate fruit listed and no vegetables listed. **Beetroot contains the highest sugar content among the vegetables, at about 8 g/ 100 g, with sucrose being the only sugar present.**

Sugars differ in quality of sweetness and taste intensity. Succharose or sucrose is distinguished from other sugars by its pleasant taste even at high concentrations. The taste intensity of oligosaccharides drops regularly as the chain length increases. Fructose > Sucrose > Glucose

No	Sugar	Sweetness value
1	Fructose	173
2	Invert Sugar	130
3	Sucrose	100
4	Glucose	74
5	Galactose	32
6	Maltose	32
7	Lactose	16

Inverted sugar syrup (also called **invert** syrup, or simply **invert sugar**) is an edible mixture of two simple **sugars**—**glucose** and fructose—that is made by heating sucrose (table **sugar**) with water. It is thought to be sweeter than table **sugar**, and foods that contain it retain moisture better and crystallize less easily.

- **Fiber** – Dietary fiber constitutes of cellulose, hemicelluloses, lignin and pectic substances. The principal constituents of cell walls are cellulose, hemicelluloses, pectins, and lignin. Pectins are one of the important components of the cell wall. The biological function of pectin is to cross-link cellulose and hemicellulose fibers, providing rigidity to the cell wall.

- **Carbohydrates in food:**

1) Food carbohydrates include the simple carbohydrates (sugars) and complex carbohydrates (starches and fiber). They occur mainly as starches and structural polysaccharides like pectins, celluloses, hemicelluloses.
2) In many of the fruits and some vegetables the starches and few other polysaccharides undergo conversion into simple sugars like sucrose, glucose and fructose during ripening. These are responsible for sweetness. Sugars constitutes major carbohydrates in fruits particularly after ripening
3) Small quantities of carbohydrates also occur as organic acids which are responsible for sourness or acidity. The major organic acids found in fruits and vegetable are citric, malic, tartaric, oxalic and pyruvic. In fruits and vegetables carbohydrates contribute mainly for its calorific value.
4) In food processing, a carbohydrate has functional role in its physical and chemical properties which act as sweeteners, thickeners, stabilizers, gelling agents, fat replacers, and precursors for aroma and coloring substances, especially in thermal processing. Carbohydrates are commonly divided into monosaccharides, oligosaccharides, and polysaccharides.

- **Cereal Carbohydrates**

1) In general, carbohydrates constitute about **75 percent of the solid content of cereals**.
2) In cereals, as in other plant tissues, carbohydrates are localized in (1) the cell wall, (there are especially thickened walls in supporting tissues of husk and seed coat) (2) plastids, where **starch constitutes the largest proportion of carbohydrates in all cereal**s, and (3) in vacuoles or the cytoplasm.
3) Cell walls are the main components of "dietary fiber".

4) Dietary fiber absorbs water and provides roughage for the bowels, assisting intestinal transit.
5) The crude fiber content of cereals varies a great deal, ranging from as low as 0.5 percent for brown rice to as high as 10.9 percent for oats.
6) The principal carbohydrate of all cereals is **starch**, representing 56 percent (oats) to 80 percent (maize) of the grain dry matter.
7) Cereal starches are similar in composition, having **74-79 % amylopectin, 25-30 % amylose, and 1 % lipids**.

Organic acids present in fruits and vegetables

1. Malic acid – Apple, Banana, Watermelon, Cherries
2. Tartaric acid – Grapes, Tamarind
3. Citric – Citrus, Pineapple, Strawberry
4. Oxalic acid – Tomato

Glycemic index (GI)

- **The glycemic index is a value assigned to foods based on how slowly or how quickly those foods cause increases in blood glucose levels.**
- The Glycemic Index (GI) is a relative ranking of carbohydrate in foods according to how they affect blood glucose levels. Carbohydrates with a low GI value (55 or less) are more slowly digested, absorbed and metabolised and cause a lower and slower rise in blood glucose and, therefore insulin levels.
- The glycemic index (GI) of F & V varies from 22 (cherries), 97 (parsnip), 55 -60 (Potato and sweet potato), 70 (Bread).
- The glucose formed by the digestion of starch and sugar is absorbed mainly through the walls of the intestine and carried to the liver. The glucose thus absorbed helps to maintain the glucose level in blood and glycogen stores in the muscles and liver. Whenever we need energy glycogen is broken down to glucose which is oxidised and energy is produced in body. Any excess glycogen is converted to fat.

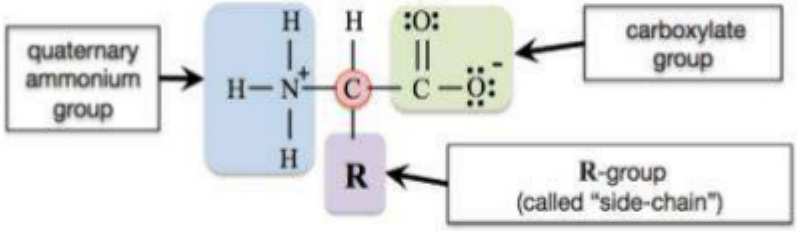
Carbohydrates	Main Food Sources	Remarks
Polysaccharides		
• Cellulose & hemicelluloses	Stalks & leaves of vegetables, Outer covering of seeds	Indigestible
• Pectins	Fruits	Indigestible
• Gums and mucilages	Plant secretions and seed exudates	Indigestible
• Starch and Dextrin	Grains, legumes, and tubers	Digestible
• Glycogen	Meats and seafood	Digestible
Disaccharides		
• Sucrose	Cane and beet sugar, molasses	Digestible
• Lactose	Milk and milk products	Digestible
• Maltose	Malt products, some breakfast cereals	Digestible
Monosaccharides		
• Glucose	Fruits Honey. Corn syrup	Digestible
• Fructose	Fruits, honey	Digestible
• Galactose	Milk	Digestible

3. Protein

Introduction

Proteins are important components of food. Every cell requires protein for structure and function. Proteins are complex polymers composed of amino acids. They are amphoteric in nature; i.e. they behave both as an acid and as a base. In their polymeric forms, they possess a regular specific folded 3-dimensional confirmation. About 20 amino acids are coded genetically, which make up food proteins. These amino acids are linked covalently by α-carboxyl group of one amino acid and α-amino group of the other amino acid through peptide linkage. Food proteins are important to texture, colour, flavor, and functional properties of food. Proteins function as buffering agents, emulsifiers, and fat mimetic agents.

Amino acids are organic compounds that contain amine ($-NH_2$) and carboxyl (-COOH) functional groups, along with a side chain (R group) specific to each **amino acid**.



Composition

Proteins are very large organic compounds. Proteins, like carbohydrates and fats, contain carbon, hydrogen and oxygen. In addition, proteins contain about **16 per cent nitrogen**, which is their unique feature and distinguishes them from carbohydrates and fats. Some proteins also contain **sulphur** and sometimes phosphorus, iron and cobalt. Proteins are more complex than fats and carbohydrates, as the size of the molecule is large and there is a great variation in the units from which it is formed. Plants are the primary source of proteins in nature. **Proteins are synthesised by the plants from the nitrates and ammonia in the soil.** Herbivorous animals use plant proteins to meet their protein needs. Man uses plant foods as also animal foods (milk and meat) to meet his protein needs.

Structure

All proteins in our body and food are built from basic units or compounds known as amino acids. Amino acids combine to form proteins by means of a peptide bond, which joins a carboxylic carbon of one amino acid with nitrogen of another. The resulting peptide has a free carboxyl at one end and a free amino group at the other, permitting addition of other amino acids at either end. The proteins are amphoteric in nature due to the presence of a free acid and a free amino group in their molecule. **Polypeptiddes thus formed constitute the primary structure of proteins.** The

secondary structure formed by linking several polypeptide chains may be helical, pleated or random coil. More complex proteins have a tertiary structure in which the polypeptide chain is wound into a globular form. Proteins consist of long chains of 100-500 amino acids that form into three-dimensional structures, their native state. When you change the native state of the protein, you change the three-dimensional structure, which is referred to as denaturation. Factors that cause denaturation include heating, acid, beating and freezing.

Essential Amino Acids: There are 22 (or more) amino acids, all of which are vital to human life and health. Essential means that we cannot synthesize them in large enough quantities for growth and repair of our bodies, and therefore, they must be included in our diet. These 9 amino acids have to be provided in the diet in sufficient amounts and are called essential amino acids. Arginine is called **semi essential,** because it may not be synthesized in sufficient amounts to meet the rapid growth of infants, especially premature ones and may need to be supplied in the diet.

Non-essential amino acids: The body is able to synthesize 13 amino acids. The word non-essential is misleading for these are necessary in the body for tissue building, repair and other metabolic functions. These are so important that the body synthesises these itself. The only reason these are termed non-essential is because these need not be provided in the diet.

Food Sources of Protein

1. Plants are the primary source of protein, because they can synthesize protein by combining nitrogen and water from the soil and carbon dioxide from the air. Animals depend on plants to fulfill their protein requirement.
2. Pulses, whole and split, nuts and oilseeds, milk, eggs, fish, poultry and meat are good sources of protein the diet. Cereals and their products are a major source of protein in the Indian dietary.
3. Milk is one animal food, which is accepted and included in menus for feast as well as fast. The quantity of milk included depends on the availability and cost.
4. Dry, salted or smoked fish and meat are inexpensive concentrated sources of protein. These contribute valuable protein in the diet of people from coastal regions.

Proteins And Their Biological Significance (Functions)

1. Proteins are the main structural and functional molecules of all living organisms.
2. Proteins are synthesized from amino acids, which are joined together by peptide bond to form a linear chain. Functions of proteins depend on the amino acid sequence.
3. These chains are then folded into various ways to form the 3 – dimensional structure of proteins.

Functions of proteins (same as classification according to function)

1. Most of the enzymes involved in the biochemical reactions in the body are protein in nature.
2. Many hormones are proteins or peptides in nature. Eg: Insulin
3. Proteins are seen in association with DNA molecules, where it controls the gene transcription and translation.
4. Proteins are involved in the transport processes. Eg: Hemoglobin in erythrocytes involved in the transport of O_2. Some transport proteins bind with steroid hormones and transport them to the other parts of the body for action. Lipoproteins transport lipids.
5. Proteins have protective role in the body. Immunoglobulins and interferons are proteins that protect humans against bacterial and viral infections.
6. Structural proteins like collagen and elastin provide structural strength and elasticity to organs and the vascular systems.
7. Some proteins are used as nutrients eg: ovalbumin of egg white and casein of milk are used as nutrients.
8. Proteins are involved in the maintenance of osmotic pressure of plasma.
9. Some proteins like actin and myosin are involved in the contraction of skeletal muscles.

Classification of Proteins

A. Based on the solubility and physical properties, proteins are classified into 3 major groups, namely,
   - Simple proteins
   - Conjugated proteins
   - Derived proteins

B. Proteins can also be classified, according to their shapes and size
   - Globular protein
   - Fibrous protein
   - Solubility and composition

C. Proteins can also be classified, according to their function
   - Catalytic proteins
   - Regulatory proteins
   - Protective proteins
   - Storage proteins etc

A. Based on the solubility and physical properties

1. Simple Proteins

- These are proteins, which on complete hydrolysis yield only amino acids as an end product.
- They are further subdivided, into
  - ***Albumins:*** These proteins are soluble in water coagulated by heat and precipitated by saturated salt solution like ammonium sulphate. Eg: serum albumin and lactalbumin

- ***Globulins:*** These proteins are insoluble in pure water, but soluble in dilute salt solutions. They may be coagulated by heat. Eg: Serum globulin, ovoglobulin.
- ***Glutelins:*** These are soluble in dilute acids and alkalis and insoluble in water and neutral solvents. Eg: glutenin from wheat.
- ***Prolamine:*** Soluble in 70 – 80 % alcohol, insoluble in water, absolute alcohol and other neutral solvents. Eg: zein of corn and glyadin of wheat.
- ***Histones:*** These proteins are soluble in water and very dilute acids, insoluble in dilute ammoniun hydroxide. These proteins are not coagulated by heat. They are strongly basic in nature due to the presence of excess amounts of arginine and lysine. Eg: Histones associated with nucleic acids.
- ***Protamines:*** Basic polypeptide, soluble in water or ammonium hydroxide, not coagulated by heat. Basic amino acids will predominate in their structure.Eg: protamines of sperm cells.
- ***Albuminoids (Scleroproteins):*** Insoluble in all neutral solvents and in dilute acids and alkalis. These are the proteins of supportive tissue. Eg: Keratins and collagen.

2. Conjugated Proteins

- These are simple proteins conjugated to non- protein substances known as prosthetic group**.**
- Further classification is based on the nature of the prosthetic group, attached to the simple proteins.

Nucleoproteins	Simple proteins associated with nucleic acids (DNA and RNA). Eg: chromatin of cell.
Glycoproteins	These are proteins having carbohydrates as prosthetic group. Glycoproteins contain less than 4% of carbohydrates whereas mucoproteins contain more than 4% of carbohydrates. Eg: mucin in saliva.
Lipoproteins	These are proteins associated with cholesterol, phospholipids and fatty acids.
Phosphoproteins	Phosphoric acid is the prosthetic group. Eg: casein in milk, vitelline in egg yolk.
Metalloproteins	These proteins are attached to various metal ions such as, copper, cobalt, iron, manganese and zinc. E.g. ceruloplasmin containing copper, carbonic anhydrase containing zinc.
Chromoproteins	Proteins are attached to colored pigments. Eg: hemoglobin, cytochromes and flavoproteins.

3. DERIVED PROTEINS

- As the name implies that these proteins are formed from simple and conjugated proteins, from the action of heat, enzymes or chemicals.
- They are sub divided into,
  - Primary derived proteins
  - Secondary derived proteins

Primary derived proteins

- The structure of these protein derivatives are slightly changed from original proteins. These are also called as denatured proteins. E.g. coagulated proteins. They are produced by action of alcohol and heat.
- Metaproteins: they are formed by the action of acid and alkali on proteins.

Secondary derived proteins

- These are smaller molecules produced by the hydrolysis of proteins.
- They are generally water-soluble and not coagulated by heat. Eg: proteases, peptones and peptides are formed by the hydrolytic cleavage of proteins.

B. According to their shapes and size

GLOBULAR AND FIBROUS PROTEINS

Globular proteins

- These are proteins, in which the polypeptide chain or chains are tightly coiled in three dimensions to form globular molecules. E.g., enzymes and plasma proteins.
- They are soluble in water.

Fibrous proteins

- Fibrous proteins are those in which the polypeptide chains are either extended or coiled to form linear fibers.
- They are insoluble in water.
- They provide mechanical support to the cells or organism. E.g., keratin (the major component of hair and nail), collagen (component of skin, bones, teeth, blood vessel and connective tissues.) and elastin (structural component of skin and blood vessels).

C. According to their function

1. **Catalytic proteins**– Enzymes having ability to function within the living cells as biocatalysts. PAL

2. **Regulatory proteins**- Hormones present in lower concentrations but play highly important regulatory role. Ex - Adrenaline

3. **Protective proteins-** Antibodies having protective defense function. Ex - Immunoglobulins

4. **Storage proteins-** Major class of proteins which store amino acids as nutrients and as building blocks for the growing embryo. Cannot be synthesized by human beings.**Globulin** is about 60-80% globulins and **albumin** 15-25%. **Prolamins and glutelins** are minor components in pulses. Ex- Globulin, Albumins

5. **Transport proteins-** Bind and transport specific types of molecules through blood. Ex - Haemoglobulin

6. **Toxic proteins**– They are toxic in nature. Ex. Sporamin present in sweet potato

7. **Structural proteins**– They serve as structural materials or as important components of extra cellular matrix. Ex - Collagen

8. **Contractile proteins-** Proteins like actin and myosin function as essential elements in contractile system of skeletal muscle.

9. **Secretary proteins** -Fibroin is a protein secreted by spiders and silkworms to form webs and cocoons.

10. **Exotic proteins-** Fishes are prevented from freezing by antifreeze glycoproteins present in their body.

4. Vitamins

Definition: Vitamins are organic substances, which occur in small amounts in foods and are necessary for life and growth.

A substance can be classified as a vitamin if it satisfies the two criteria:

1. It must be a vital, organic dietary substance, which is neither a carbohydrate, fat, protein, or mineral and is necessary in only very small amounts to perform a specific metabolic function or to prevent an associated deficiency disease, and

2. It cannot be manufactured by the body, and, therefore, must be supplied by the diet.

Vitamins do not provide calories, but are essential in the metabolic reactions, which release energy from carbohydrates, fats and proteins. Each vitamin has specific functions and so **one vitamin cannot substitute for another in the body.** Vitamins may occur in preformed or its active form in the food, or as a precursor compound which can be changed into active form in the body.

Vitamins are conveniently classified into two groups on the basis of their solubility into **fat soluble and water-soluble vitamins**. Fat-soluble vitamins include A, D, E and K. Water-soluble vitamins include the B-group and vitamin C.

FAT-SOLUBLE VITAMINS

Fat-soluble vitamins can only be **absorbed in the presence of fat**. Therefore, the presence of some fat in the diet is essential for their absorption. Fat-soluble vitamins **can be stored in the body** and hence occasional intake of very high sources may help the body tide over periods of low intake. The requirement for fat-soluble vitamins may be met by **intake of a precursor or the vitamin** itself. Usually Fat soluble vitamins are **not lost** in normal cooking procedures.

Vitamin A (Retinol / Carotenoids)

This was **the first fat-soluble vitamin to be discovered**. It has a number of important functions in the body. Vitamin A is found only in animal foods, mainly as **retinol**. Plants provide a source of vitamin A for animals in the form of orange-yellow pigments called the carotenoids. The chief source in human nutrition is **beta-carotene**, which the body converts to vitamin A. The conversion is partial and varies from **25 to 50 per cent**.

Three different forms of vitamin A are active in the body: **retinol, retinal, and retinoic acid.** These are known as retinoids. The cells of the body can convert retinol and retinal to the other active forms of vitamin A as needed.

- **Food source: Vitamin A (Retinol) is present in animal foods only.** Liver is the richest source of vitamin A. Retinol is found in liver, egg yolk, butter, whole milk, and cheese. **Precursor of**

Vitamin A i.e. carotenoids (β-carotene) are found in orange-flesh sweet potatoes, orange-flesh fruits (i.e., melon, mangoes, and persimmons), green leafy vegetables (i.e., spinach, broccoli), carrots, pumpkins, and red palm oil. Generally, dark green leafy vegetables contain greater amounts of carotene than those which are light in colour

- **Functions:** Vitamin A is necessary for normal growth and development. If the intake of vitamin A is not sufficient for normal growth, the bones will stop growing, before the soft tissues are affected. Vitamin A plays a central role in our vision, skin, genes, growth, and immune system. It is especially important during the early stages of pregnancy in supporting the developing embryo.
  Function in Vision: Vitamin A occurs in the retina of the eye and is required in the process of vision to adjust to light of varying intensity (dark adaptation). If more vitamin A is not available, ability to adjust to changes in intensity of light is affected.

- **Deficiency:** About 90% of vitamin A is stored in the liver. Vitamin A deficiency can lead to night blindness, skin disease and growth retardation in children. Night blindness occurs in severe vitamin A deficiency; it indicates the inability of a person to see at night, when the amount of light is far too little to permit adequate vision. Vitamin A deficiency may sometimes cause degeneration of nervous tissue without causing bone malformation. Excessive intakes of pre-formed vitamin A can result in high levels of the vitamin in the liver – a condition known as **hypervitaminosis A**. No such risk has been observed with high β-carotene intakes.

Vitamin D (Calciferol)

Pure vitamin D was isolated in crystalline form in 1930 and was called **calciferol**. Vitamin D is now considered a pro-hormone than a vitamin. Vitamin D is sometimes called the '**sunshine vitamin'** because the body is able to convert a precursor (derived from cholesterol) 7-dehydrocholesterol, a sterol present in the skin, to vitamin D in the presence of sunlight. It can be synthesized in the body in adequate amounts by simple exposure to sunlight even for five minutes per day. Vitamin D is therefore **not an essential micronutrient**, given the right season and enough time in the sun. The active from of vitamin D is actually a hormone that targets organs – most notably the intestines, kidneys, and bones.

- **Functions:** Vitamin D performs several important functions in the body. These include:
  - **Absorption of calcium and phosphorus: calcitriol**, a hormone, is an activated form of vitamin D. In the intestine, vitamin D is **involved in the absorption of calcium and phosphorus.** In the bone, it assists in the absorption of calcium and phosphorus**, helping bones grow denser and stronger** as they absorb and deposit these minerals.
  - **Bone mineralisation:** The bone tissue formation from calcium and phosphorus and other materials is regulated by calcitriol. **It regulates the rate of deposit and resorption of these minerals in bone.** This balancing process helps to build and maintain bone tissue.

- Vitamin D hormone can be used to treat rickets in children and osteoporosis (bone loss) in older women.

- **The primary sources of vitamin D:** Sunlight – exposure to ultraviolet B (UVB) rays is necessary for the body to synthesize vitamin D from the precursor in the skin. **Foods are not a good source of vitamin D.** It is found in small quantities in liver, egg yolk, milk and milk fat (butter and ghee), obtained from animals fed on pastures exposed to sunlight. The richest source known is **fish liver oils**. Fish liver oils do not form part of the diet and have to be taken as a supplement. Vitamin D is also present in mushrooms.
- **Deficiency:** One of the main roles of vitamin D is to facilitate the absorption of calcium and phosphorus. Consequently, a vitamin D deficiency creates a calcium deficiency, with significant consequences to bone health. Among children and adolescents, it may cause **rickets** and adversely affect peak bone mass. In adults, vitamin D deficiency increases the risk of **osteomalacia and osteoporosis**.

Vitamin E (α-Tocopherol)

Vitamin E or alpha-tocopherol is a fat-soluble vitamin. The most active form of vitamin E is **α-tocopherol,** which acts as an antioxidant (i.e., stops the chain reaction of free radicals producing more free radicals).

- **Functions:** The main function of vitamin E, tocopherol, is its ability to prevent tissue breakdown, by virtue of its antioxidant nature. **Vitamin E acts as nature's most powerful fat-soluble antioxidant.** Vitamin E protects cell membranes, proteins, fatty acids, Vitamin A, carotenes and DNA from oxidation. Selenium is a trace mineral that works as a partner with vitamin E as an anti-oxidant.
- **Food source:** Vitamin E in the α-tocopherol form is found in edible vegetable oils, especially wheat germ, and sunflower and rapeseed oil. Other good sources of vitamin E are leafy green vegetables (i.e., spinach, chard), nuts (almonds, peanuts) and nut spreads, avocados, sunflower seeds, mango and kiwifruit.

Deficiency: No definite proof of vitamin E deficiency in human beings has been established. Vitamin E deficiency leads to red blood cell breakage and nerve damage. Excessive intake of vitamin E from food is very rare. Vitamin E is stored in the liver and is safe even at high intakes.

Vitamin K (Phylloquinone)

Phylloquinone is the major form of vitamin K found in plants. It is also the form found in our dietary.

- **Function:** The basic function of vitamin K is in the blood-clotting process. It is essential for the formation of **prothrombin** by the liver. Prothrombin is a normal constituent of the blood and helps clotting of blood on contact with air. Deficiency of vitamin K prolongs clotting time and may result in excessive bleeding after an injury.

- **Food source:** Green leafy vegetables are the principal dietary source of vitamin K. Sources of phylloquinone are green leafy vegetables cabbage, and vegetables oils (soybean, canola, olive).
- **Deficiency:** Vitamin K deficiency causes **hemorrhagic disease (uncontrolled bleeding)** results. Human babies do not have reserves of vitamin K at birth and in many hospitals it is, therefore, routine practice to give vitamin K to the expectant mother to prevent excessive bleeding at child birth.

WATER SOULUBLE VITAMINS

Water-soluble vitamins consist of ascorbic acid and the B-complex vitamins. **The water-soluble vitamins are absorbed quickly in the body and the amounts not utilized are excreted in the urine.** Adequate amounts should, therefore, be **supplied in the daily diet**. Some of the water-soluble vitamins are **partly lost in cooking** procedures. This factor has to be kept in mind while meeting their requirements.

Vitamin B-Complex

Six members of this group, namely, thiamin, riboflavin, niacin, pyridoxine, folic acid and vitamin B12 are included in the RDA, because definite requirements of these vitamins have been established through research. A diet, which provides adequate amount of these six vitamins, also, carries enough of the other members of this group. All these vitamins are essential for human nutrition.

Vitamin B1 (Thiamin)

The main source of thiamin in the Indian dietary is **cereals** but refining of cereals reduces thiamin content with most of the thiamin being lost in the polishing.

- **Functions:** Thiamin is a sulfur-containing vitamin that participates in energy metabolism, converting carbohydrates, lipids and proteins into energy. Thiamin is needed to maintain normal function of three systems in the body, **gastrointestinal, nervous and cardiovascular system** (nerve, muscle, and heart function).
- **Food source:** Liver, kidneys, heart, fish, meat, whole grain cereals, leafy green vegetables, asparagus, eggplant, fruits , legumes (beans and lentils), nuts, soymilk, squash, brewer's yeast.
- **Deficiency: Thiamine** deficiency can lead to two major health problems: **beriberi and Wernicke-Korsakoff syndrome**. People who consume diets consisting of primarily **refined grains** (mostly milled flours and polished rice) are at risk for thiamin deficiency. The risk of inadequacy is less when food **manufacturers fortify refined grains with vitamin B1**. **Clinical vitamin B1 deficiency is called beriberi**. In beriberi, there is damage to the nervous system characterized by muscle weakness in the arms and legs, or damage to the cardiovascular system which is characterized by dilated blood vessels, causing the heart to work harder and the kidneys to retain salt and water, resulting in edema. No adverse effects have been associated with excessive thiamin intakes.

Vitamin B2 (Riboflavin)

Riboflavin, a more heat-stable factor, was discovered after thiamin. When in solution, riboflavin is destroyed on exposure to sunlight. For example, prolonged exposure of milk to direct sunlight may decrease the riboflavin content of milk considerably.

- **Function:** Vitamin B2 participates in releasing energy from carbohydrates, fats and proteins. Vitamin B2 stimulates growth and reproduction, plays a role in vision, and in the conversion of vitamins B6, folic acid, and niacin into their active coenzyme forms.
- **Food source:** Milk and milk products is a rich source of riboflavin. There is no riboflavin in butter and ghee because the vitamin is water-soluble and remains in the water extract during the removal of butter from milk or curds. Vitamin B2 is found in liver, kidneys, heart, eggs, meat, milk, yogurt, cheeses, whole grain cereals, pulses, dark green leafy vegetables, and brewer's yeast.
- **Deficiency:** Lack of riboflavin affects the eyes, skin and nerves. The eyelids become rough and the eye becomes sensitive to bright sunlight. This condition is called photophobia (fear of light). The skin changes are found around the area of the mouth, on the lips, tongue and nose

Vitamin B3 (Niacin)

Niacin is unique in that it can also be synthesized from the amino acid **tryptophan**. It occurs in two forms**: niacinamide and nicotinic acid.**

- **Function:** Niacin acts as coenzyme in energy-transfer reactions, especially the metabolism of glucose, fat, and alcohol. It also protects against neurological degeneration**The primary sources of vitamin B3:**
- **Food source:** Liver, fish, meat, milk, eggs, whole grain cereals, legumes, fruit (avocados, figs, dates, prunes), and nuts. Other: Synthesized from tryptophan
- **Deficiency:** Severe niacin deficiency results in a disease called **pellagra** and its symptoms are **dermatitis, diarrhea, dementia and eventually death**.

Vitamin B5 (Pantothenic Acid)

Vitamin B5 is part of the structure of **coenzyme A**, which is involved in the synthesis of fatty acids and is important for converting foods into fatty acids and cholesterol.

- **Function:** Vitamin B5 is important for maintenance and repair of tissues and cells of the skin and hair, helps in healing of wounds and lesions, and pantethine, which is a form of vitamin B5, normalizes blood lipid profiles. As with all B vitamins, pantothenic acid helps the body break down fats, carbohydrates, and proteins so that our bodies can use them for energy and rebuilding tissues, muscles, and organs.

- **Food source:** Vitamin B5 is found in liver, kidneys, meat (chicken), egg yolk, milk, fish, whole grain cereals, potatoes, tomatoes, broccoli, and mushrooms.
- **Deficiency:** Vitamin B5 deficiency is very rare and symptoms involve a general failure of all the body's systems. Symptoms include fatigue, nausea, vomiting, headaches, tingling sensations ("burning feet" syndrome). No adverse effects have been reported with high intakes of vitamin B5.

Vitamin B6 (Pyridoxine)

It occurs in three forms: **pyridoxal, pyridoxine, and pyridoxamine.** Vitamin B6 is stored in muscle tissue.

- **Function:** Vitamin B6 is required for the majority of biological reactions (i.e., amino acid metabolism, neuro- transmitter synthesis, red blood cell formation).
- **Food source:** There are many good sources of vitamin B6, including chicken, liver, fish, nuts (walnut, peanut), chickpeas, maize and whole grain cereals, and vegetables (especially green leafy vegetables), bananas, potatoes and other starchy vegetables are also good sources.
- **Deficiency:** Deficiency of vitamin B6 alone is uncommon; usually it occurs in combination with a deficiency in other B-vitamins.

Vitamin B7 (Biotin / Vitamin H)

- **Function:** Biotin plays an important role in metabolism as a coenzyme that transfers carbon dioxide. This role is critical in the breakdown of food (carbohydrates, fats and proteins) into energy. Biotin is involved in many cellular reactions, particularly in fat and protein metabolism of **hair roots, finger nails, and skin**.
- **Food source:** Eggs, milk, vegetables, cereals, nuts (almonds, walnuts, peanuts), liver, kidney, yeast, soybeans. Other: synthesized by intestinal bacteria.
- **Deficiency:** Symptoms of deficiency include general fatigue, nausea, neurological problems, poor skin and hair quality. No adverse effects have been reported with excessive intakes of biotin.

Vitamin B9 (Folate)

Folate refers to the naturally occurring forms (pteroylglutamic acid) as well as the forms found in fortified foods and supplements (folic acid). **Folic acid is the most stable form of folate**.

- **Function:** The primary function of folate is as a coenzyme, THF (tetrahydrofolate) that transfers single carbon in the synthesis of a number of metabolites in the body. It is also involved in the synthesis of nucleic acid along with vitamin B12. Without vitamin B12, folate is unavailable to support cell growth. Folate is essential for brain development and function.
- **Food source:** Dark green leafy vegetables, beans, lentils, asparagus, wheat germ, yeast, peanuts, oranges, strawberries. Folate is easily destroyed by heat and oxygen.

- **Deficiency:** Prolonged and severe folic acid deficiency leads to abnormal formation of red blood cells resulting in **megaloblastic anaemia**. Folate requirements are increased during pregnancy, especially in the first couple of weeks of gestation. Folate deficiency is highly associated with the risk for **neural tube defects in the growing fetus**. Thus, women of child-bearing age and pregnant women are advised to meet folate requirements using a combination of natural foods (folate forms) and fortified foods or supplements (folic acid). **In many western countries, governments have mandated flours to be fortified with folate.** Because folate is critical for cell growth and repair, especially for cells with a short life span, such as cells in the mouth and digestive tract, visible signs of folate deficiency include digestive problems. Other symptoms are tiredness, loss of appetite, fewer but larger red blood cells (megaloblastic or macrocytic anemia), and neurological problems. **A vitamin B12 deficiency will provoke a folate deficiency** because it means vitamin B12 is not available to donate its methyl group to convert folate into its active form.

Vitamin B12 (Cobalamin)

- **Function:** Vitamin B12 functions as a coenzyme in the conversion of homocysteine to methionine, in the metabolism of fatty acids and amino acids, and in the production of neurotransmitters. It also maintains a special lining that surrounds and protects nerve fibers, and bone cell activity depends on vitamin B12. Folate and vitamin B12 are closely related. When folate gives up its methyl group to B12, it activates this vitamin.
- **Food source:** Vitamin B12 is found **only in foods of animal origin**, except where plant-based foods have been fortified. Rich sources of vitamin B12 include fish, liver, meat, milk and milk products.
- **Deficiency:** About 10–30% of older adults are estimated to have chronic inflammation of the stomach, a condition that impairs the absorption of vitamin B12. It is advised that older adults consume **fortified foods or supplements to meet their vitamin B12 requirements**. Vegans (individuals who do not consume animal-source foods), who do not take fortified foods or supplements, will develop vitamin B12 deficiency. Symptoms of vitamin B12 deficiency include **anemia, general fatigue, loss of appetite, gastric atrophy, neuromuscular pain, neurological problems (gait, memory loss)**. No adverse effects with excessive intakes of vitamin B12 have been reported.

Vitamin C (Ascorbic Acid)

Vitamin C acts as an antioxidant or as a cofactor, helping a specific enzyme perform its job.

- **Function:** Vitamin C has multiple roles - in the synthesis of collagen, absorption of iron, free radical scavenging, and defense against infections and inflammation
- **Food source:** Fruits (especially citrus fruits), cabbage-type vegetables, green leafy vegetables, lettuce, tomatoes, potatoes, and liver.

- **Bioavailability of vitamin C:** Levels of vitamin C in foods depend on the growing conditions, season, and stage of maturity, cooking practices, and storage time prior to consumption. **Vitamin C is easily destroyed by heat and oxygen.** Absorption levels depend on the amounts consumed. About 70–90% of vitamin C is absorbed.
- **Deficiency:** Because smoking generates free radicals, individuals who smoke have elevated requirements for vitamin C. Vitamin C deficiency can cause **scurvy**; signs of scurvy are bleeding gums, small hemorrhages below the skin, fatigue, loss of appetite and weight, and lowered resistance to infections.

Vitamin Name	Major Functions	Deficiency Effects	Toxicity Effects	Food Sources
A Retinol, retinal, Retinoic acid, (Beta carotene)	Vision, immunity, reproduction and growth	Blindness, infections, stunted growth	Bone fractures, liver damage, birth defects	Fortified milk, eggs, liver (dark green leafy and yellow/orange vegetables)
D Cholecalciferol	Bone growth and maintenance, absorption of calcium	Rickets, osteomalacia	Calcium imbalance	Sunlight, fortified milk, fatty fish, eggs, liver
E Tocopherol	Antioxidant, protects cell membranes	Red blood cell breakage, nerve damage	Interferes with blood-clotting drugs	Vegetable and seed/ nut oils, seeds and nuts, wheat germ and whole grains
K Phylloquinone	Blood clotting, bone health	Hemorrhage	None reported	Dark leafy greens, cabbage family, liver
B1 Thiamin	Energy metabolism	Beriberi, neurological problems	None reported	Whole and enriched grain products, leafy greens, pork
B2 Riboflavin	Energy metabolism	Inflammation of the mouth, skin	None reported	Whole and enriched grain products, milk products
B3 Niacin	Energy metabolism	Pellagra	Niacin flush, liver damage, impaired glucose tolerance	Whole and enriched grain products, protein-rich foods
B5 Pantothenic acid	Protein, fat and carbohydrate metabolism	Extremely rare	Mild intestinal distress	Almost all foods, especially avocadoes, broccoli, meats
B6 Pyridoxine, pyridoxal, pyridoxamine	Protein and fat metabolism	Scaly dermatitis, anemia, convulsions	Nerve degeneration	Protein-rich foods
B7 Biotin	Protein, fat and carbohydrate metabolism; beneficial to hair, skin and nails	Extremely rare	Unlikely	Egg yolk, liver, peanuts; also produced by gut bacteria
B9 Folate, folic acid, folacin	Helps make DNA for new cells, activates B12	Anemia, birth defects	Masks a B12 deficiency	Fortified grain products, vegetables, legumes
B12 Cobalamin	Helps make DNA for new cells, activates folate, protects nerve cells	Anemia, irreversible nerve damage and paralysis	None reported	Meat, fish, poultry, eggs, milk products
C Ascorbic acid	Antioxidant, collagen synthesis, immune function	Scurvy	Diarrhea	Fruits and vegetables

Chapter 4. Fortification and Enrichment of Food

Definition Fortification - The addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated nutrient deficiency in the population or specific population groups (Food and Agriculture Organization FAO, 1996).

Fortified foods usually have nutrients added that don't occur naturally in the food product. The goal for any food fortification is to increase the nutrient intake for the target population to as close as possible to the recommended intake, while at the same time maintaining safe levels of intake for all persons.

Definition Enrichment - The word '**enriched**' means nutrients have been added back to replace the ones that were lost during processing.

Two other terms for the addition of nutrients to foods are used:

Restoration (the replacement compensates for losses during production, e.g., vitamin C to juices and nectars, B vitamins to flour); and S**ubstitution** (addition to a substitute product to the levels in the food, which it is designed to resemble; e.g., vitamin A to margarine).

Common added nutrients' include calcium, vitamin C, potassium, iron, protein or fiber. The practice of adding essential nutrients to foods was first introduced in the 1920s to reduce deficiency disorders, which were prevalent at that time in the United States and Europe.

- **General principles for the addition of essential nutrients to foods:**

1. There should be a demonstrated **need for increasing the intake of the nutrient** in one or more target (population) groups. This may be in the form evidence of deficiency of the nutrient or possible deficiency likely to develop because of changes taking place in food habits.

2. The food selected as a vehicle for the nutrient should be **consumed by the population** at risk.

3. The intake of the food selected as a vehicle for the essential nutrient should be **stable and uniform**, and the lower and upper levels of intake should be known.

4. The amount of nutrient added should be **sufficient to correct or prevent deficiency** when the food is consumed in normal amounts by the population at risk.

5. The amount of nutrient added should not result in **excessive intakes** by individuals with a high intake of a fortified food.

- **ENRICHED FOODS**

The word '**enriched**' means nutrients have been added to replace the ones that have disappeared during the manufacturing process. Many refined grains are enriched.

For example, whole wheat is rich in B-complex vitamins and iron that live in the outer parts of the grain, which is called the hull. Whole wheat is nutritious and good for you, but most people prefer to use white flour for their bread, pastries and other baked products. So food manufacturers refine the whole wheat by removing the hulls, creating white flour. Of course, eliminating the hulls also removes most of the B-complex vitamins and iron so they're added back into the flour before packaging and shipping to grocery stores and restaurants.

Enrichment is regulated to protect consumers. According to the FDA (Food Drug Administration USA), foods can claim to be enriched if they **"contain at least 10 percent more of the Daily Value of that nutrient than food of the same type that is not enriched."**

➢ FORTIFIED FOODS

- Fortified foods have extra nutrients added by food manufacturers, but they're not necessarily meant to replace nutrients that were lost during processing.
- Food fortification can help provide nutrients that tend to be deficient in the diet. For example, one of the very **first fortified foods in the United States was iodized salt.**
- Fortified foods usually have nutrients added that don't occur naturally in the food product. **The idea is to make the food healthier by supplementing it with additional nutrition.**
- In the early 1900s, goiter (a disease of the thyroid gland) was relatively common in areas where iodine was deficient in the soil. In **1924, some salt makers added iodine to their product,** which helped reduce the number of new cases of goiter dramatically within a short time.
- **Milk was first fortified with vitamin D in 1933 to ensure that a sufficient amount of calcium** would be absorbed. A vitamin D deficiency can lead to rickets in children and osteoporosis in adults.
- Fortified products in market - calcium-fortified orange juice, phytosterol-fortified margarine and vitamin and mineral fortified breakfast cereals, extra nutrients in eggs, omega-3s (the hens are fed omega-3 rich feed like flax), plant sterol in buttery spreads to help improve blood lipids and more.
- Fifty countries including the United States, Canada, and Australia require mandatory fortification of certain staple foods with specific nutrients.

Iodized salt. Salt producers are a key partner in combating **Iodine Deficiency Disorders (IDD)** today throughout the world. Iodine is an essential element in healthy human life enabling the function of our thyroid gland. Too little iodine can produce a thyroid enlargement known as a **goiter;** more significantly, iodine deficiency impairs fetal brain development. Iodine can be difficult to get naturally but, when we eat seafood, plants grown where soil contains iodine and the meat of animals whose forage grows in such soils, our bodies usually take in enough iodine. David

Marine (1880-1976) is the "father" of iodized salt in the United States. **Iodized salt is the first of what we now term "functional foods.**

Advantages of Fortification and Enrichment:

1. Food fortification has most likely played an important role in the decline of deficiency diseases, e.g., **niacin fortification of flour and bread in the elimination of pellagra**, **iodine fortification of salt in the decline of goiter**, and **vitamin D fortification of margarine and milk in the disappearance of rickets**. More recently **folic acid fortification** of cereal products has proved effective in the decline of neural tube defects.
2. Fortification has proved to be a **cost-effective method of increasing micronutrient intakes** in populations.
3. Fortification also has the distinct advantage of requiring **less change in consumer behaviours** than the other nutrient interventions. It does not require people to change their eating habits
4. It does not affect **organoleptic** properties.
5. Worldwide, more than 2 billion people have micronutrient deficiencies because they aren't getting enough essential vitamins and minerals each day. Fortification can be **introduced easily and quickly** through existing marketing and distribution system.
6. Older adults, pregnant women and children are particularly vulnerable to nutrient deficiencies. Without added vitamins and minerals, they may not meet daily nutrient requirements.
7. People with special diets usually have potential vitamin deficiencies. Vegans, for example, can benefit from foods fortified with vitamin B-12.

Disadvantages of Fortification and Enrichment:

1. Pregnant women and older adults can get **too much vitamin A**. It can cause birth defects, and high levels of vitamin A have been linked to hip fractures in older adults.
2. **Outdated Daily Value** guidelines are also a concern. This means that many fortified or enriched foods may be within Daily value limit, but may in fact have more nutrients than is necessary or safe.
3. Many fortified or enriched foods are **heavily processed and packaged**. They often come with high sodium, fat, and sugar content.
4. Fortified and enriched foods, especially foods not formulated for children, may **not be safe for all children.** Children should not eat more than 20 to 25 percent of the adult recommended daily value for vitamin A, niacin, and zinc.
5. You can't cover poor nutrition by adding extra vitamins. Healthy diet should be primary source of all nutrients.