NUTRITIONAL BIOCHEMISTRY

Nutrition and Dietary Habits

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Introduction and definition of food and nutrition

Nutrition is a science of food and its relationship to health. Nutrition refers to nourishment that sustains life. The study of nutrient requirements and the diet providing these requirements is also known as 'nutrition'. Pike and Brown, 1984 defined it as "the science that interprets the relationship of food to the functioning of living organism. It includes the uptake of food, liberation of energy, elimination of wastes and all the processes of synthesis essential for maintenance, growth and reproduction".

Knowledge of nutrition is based on two fundamental areas of science: physical & behavioral sciences. The physical sciences -biochemistry and physiology, help us to know how nutrition is related to our physical health & well-being. The behavioral sciences like psychology help us to understand how nutrition is interwoven to the unique human nature. It is a relatively new science with roots in physiology and biochemistry and is interrelated to various other subjects like Medicine, Agriculture, Food science & technology, Biochemistry, Biological sciences, Economics, Psychology, etc.

'Balanced diet' is defined as that 'diet providing adequate nutritional needs as well as extra allowance for stress from different foods belonging to different food groups in specific quantities and proportions'. Since all foods don't have similar nutritional quality, the nutrients provided and thus the health depends on the choice & quantity of foods selected. For a healthy & active life, diets should be planned on sound nutritional principals. Optimum nutrition /adequate nutrition or good nutrition is a diet "that provides all dietary nutrients in respect of kind and amount, and in proper state of combination or balance, so that the organism may always meet the varied exogenous and endogenous stresses in life, whether in health or disease, with a minimal demand or strain on the body's natural homeostatic mechanisms" (Krehl, 1956). Thus while planning the diet, in addition to the calorific value, the quantity and quality of food is taken into consideration. The three proximate principles of food are Protein, Carbohydrate and Fat. The main energy food sources are carbohydrate and fats; whereas for growth and development protein food sources are required. Deficiency, excess or imbalance of nutrients results in malnutrition, which could be either under nutrition or overnutrition. Proper nutrition is required for prevention of illness as well as for treatment of the illness. A combination of different foods is required to be included in the diet as no single food meets all the nutrient requirements. For convenience in planning of a meal, different foods have been grouped based on their function and major nutrient contribution. These are:

1. Milk and its products;
2. Meat/Poultry;
3. Cereal;
4. Pulses/Legumes;
5. Fruits;
6. Vegetables;
7. Fats & Sugar

Though there are number of factors affecting the health of an individual; nutrition/ food/ diet is an important component. Nutrients provided to our body by a balanced diet helps in proper growth and development. One of the fundamental basic requirements for health is good nutrition as it not only promotes growth and development but also provides immunocompetence and

affects cognitive development. Studies have indicated that kind of nutrition in early life (especially intrauterine and infancy) affects disease processes in adult life. With the changing lifestyle modifications in the world, including a change in the quantity and quality of food supply & intake; nutrition is emerging as an important tool for promoting health and for prevention/reducing the risk of many diseases.

Factors determining food acceptance/choice

Food choice is an important determinant of health and nutritional status of a person. Various complex blend of factors affecting the personal food acceptance/choices/ habits which varies from individual to individual are as follows-

- Environmental influences: Economic, lifestyle, cultural, religious beliefs & traditions.
- Sensory: flavor (taste & smell), texture & appearance.
- Cognitive: learned food habits, emotional requirements, social factors & advertising.
- Genetics: preferences for certain tastes & sensitivity
- Health status: any restriction due to disease or due to age (e.g. declining taste sensitivity).

Regulation of body temperature

It is known that humans beings are warm blooded and thus are able to regulate its internal temperature. This is done by the heat/energy by the metabolism of food in the body. The ability to keep the body temperature within certain limits despite changes in external environment is called thermoregulation. There may be differences in the heat production and heat loss in different parts of the body, the circulating blood helps to bring it to a mean temperature. Two ways of thermo regulation used by mammals is:

1) Physiological regulation: during cold weather the body adapts to different mechanisms to regulate body temperature- like constriction of surface capillaries or shivering which raises the metabolic rate. In hot weather the body sweats to lower the body temperature.
2) Behavioral regulation: a person after sitting in the sun to warm up may want to cool down and thus may shift into the shaded area.

Some variations observed in body temperature in relation to food are:

- Specific food intake- may cause increase or decrease in body temperature.
- Alcohol intake- produces a fall in body temperature.

Physiology and nutrition of carbohydrates, fats, proteins and water

Carbohydrates

Carbohydrates $C_x (H_2O)_y$ / $(CH_2O)_n$ is one of the macronutrients- a major energy source to the body. It provides 4kcal/g. Carbohydrates in food are present in the form of sugars and starch (polymers of sugar) and cellulose (non-starch polysaccharide). The simplest component of carbohydrate is glucose.

Classification

Carbohydrates are classified into mono, di, oligo and polysaccharides. There are six naturally occurring carbohydrates of interest in foods -glucose, fructose (monosaccharides- are simplest form of carbohydrate and can not be hydrolyzed further.); sucrose, maltose and lactose (disaccharides) and starch (polysaccharide). Simple carbohydrates (sugars) are crystalline solids and water-soluble.

- Glucose (also called Dextrose /grape sugar/ corn sugar) is the simplest monosaccharide and is widely available in nature. It is the major energy fuel for the human body.
- Fructose (also known as Levulose / fruit sugar) is about twice sweeter than sucrose. It is used as sweetener by diabetics or obese people. It is also observed that fructose does not require insulin hormone for utilization.
- Maltose (Malt sugar) – is an intermediate product of starch digestion. It is also present in malted and fermented grains. Maltose (malt sugar) on hydrolysis yields two glucose units.
- Sucrose on hydrolysis yields equal parts of glucose and fructose.
- Lactose (milk sugar) provides equal quantities of glucose and galactose on hydrolysis.
- Polysaccharides (starch, glycogen) provide a number of monosaccharide units on hydrolysis. But the uncooked starch in food is not easy to digest, as the digestive juices can't penetrate the cell wall of plant, which contains the starch. Gelatinization of starch (powdered form) occurs when it is mixed with water and heated to 85^0 C, and this on cooling leaves a semisolid gel.

  Glycogen is the reserve carbohydrate in man and animals present in liver and muscles and is synthesized from glucose.

  Pectin found in soft fruits and in plant cell walls is a mixture of polysaccharides. Cellulose on hydrolysis by acids yields high number of ß-D glucose.

  Starch (polymers of sugar-having a high molecular weight) is non-crystalline, insoluble in water and tasteless. Cereals have about 70% whereas legumes seeds have 40%of starch. Starch present in seed and roots of plants is composed mainly of two components amylose and amylopectin. Glucose units (α1, 4 linked) in a long unbranched chain are called amylose whereas highly branched unit with α1, 6 linked glucose units is amylopectin. Amylose starch produces blue colour on reaction with iodine. Starch is readily hydrolyzed by acids to glucose.

Metabolism

The digestion of carbohydrates starts in the mouth by the action of saliva and is finally broken down to the simplest unit which is absorbed in the small intestine. Carbohydrate digestion involves hydrolysis of disaccharide and polysaccharide to simple sugars. The monosaccharides are transferred across epithelial cells and enter portal vein, with faster absorption of glucose and galactose than fructose. The series of reactions involving assimilation, utilization of glucose by body, is controlled by hormone insulin.

Ribose, xylose and arabinose are present in fruits and root vegetables. These are 5 carbon sugars (Pentoses- monosaccharides) and are of significance as are constituent of riboflavin (Vitamin B), RNA and DNA. These are not required in diet as these can be synthesized by all animals.

The non-digestible carbohydrates - cellulose, hemi cellulose, gums, mucilage, pectin and lignin in plant foods is called 'dietary fiber'. This is now also referred to as 'non-starch polysaccharide (NSP). They are classified as soluble and insoluble dietary fiber. They do not provide any nutritive value, but are helpful in many ways. Cellulose has a high molecular weight, is non-crystalline, insoluble in water and tasteless.

A normal value for blood glucose is 80-120mg/dl. Depending on the type of carbohydrate it has effect on the blood glucose levels. Glycaemic Index (GI) is the blood glucose response after having a carbohydrate meal. GI is affected by number of factors such as physical characteristics of food (intact or ground form), cooked or uncooked food, fibre content of food, presence of fat and protein in the diet.

Functions

- Major energy providing nutrient in the diet. Has protein sparing action;
- The dietary fiber non-digestible carbohydrate help in various ways -stimulates contraction of digestive tract, add bulk to the stool; retards gastric emptying. Soluble fibers help on lowering the blood cholesterol and blood glucose levels;
- Different starches are used as thickening agents e.g. corn flour; arrowroot powder;
- Helps in growth of desirable bacteria eg. lactose;
- Pentoses are components of DNA and RNA.

Deficiency

In case total energy requirement is not met by the diet, especially in young infants and children, malnutrition occurs.

Recommended Dietary Allowance

It has been recommended that carbohydrate in the diet be 55-65% of total energy with emphasis on complex carbohydrate. 40gm of dietary fibre in the daily adult diet is recommended (FAO/WHO, 1998).

Dietary Sources

It is present in variable amount in nearly all foods except fats and oils. Starch, sugar, grain foods, roots and tubers are the main carbohydrate source. For dietary fibre bran is the richest source. In addition whole grains cereals, legumes, nuts, fruits and vegetable are good fibre source.

Fig. 1: Carbohydrate sources

Fats

Fats are triglycerides of fatty acids and glycerol. Fatty acids have a fundamental structure of CH_3 $(CH_2)_n$COOH. Fat is a concentrated source of energy providing 9kcal/g.

Classification

Based on the linkage between the carbon atoms, they are classified as saturated (carbon atoms linked by a single bond, e.g. denoted as 14:0); Monounsaturated (one double bond in the carbon chain, e.g. 16:1,n-9 denotes fatty acid with 16 carbon atoms); Polyunsaturated (more than one double bond, e.g. 20:4n- 6, denotes carbon atom with first of four double bond in 6 carbon atoms from methyl group).

The degree of unsaturation affects the properties of the fat /oil. All double bonds are usually in cis forms. The trans fatty acids are unsaturated fatty acids having double bond in the trans form, which is found to be more stable. But number of studies has indicated the association between adverse effects of trans fatty acids and coronary heart disease and lipoproteins profile. It is emphasized that the food industry reduces the trans fatty acids in its products. Fatty acids in food have even number of carbon atoms and have a mixture of fatty acid triglycerides. Due to the hydrophobic nature of fatty acids containing more than 8atoms, it is insoluble in nature. Fats are solid at room temperature and contain more percentage of saturated fatty acid. Oils are liquid at room temperature containing more of unsaturated fatty acids. Animal fats predominantly have saturated fatty acids whereas the vegetable oils have unsaturated fatty acids.

Metabolism

The digestion of fat takes place in small intestine with the help of bile and lipase enzyme into fatty acids and glycerol. These are again resynthesized into triglyceride in the intestinal cell. The triglyceride is transported by lipoproteins, via lymph to blood where the small- chain triglycerides are absorbed directly into capillaries. Fats release 9 kcal per gm of fat.

Vegetable oils are extracted of from seeds, nuts and kernels. It is done either with the help of solvents or by mechanical pressure. The vegetable oils obtained may have some impurities such as gums, resins, coloring matter, free fatty acid etc. These are removed with the help of refining process, including a number of processes like degumming, neutralizing, washing and drying, bleaching and deodorizing. Care needs to be taken to prevent air contact as it causes deterioration due to oxidation.

Rancidity- The spoilage of oils and fats resulting in unpleasant odors and flavors is called rancidity. Two types of rancidity are known - hydrolytic and oxidative. Hydrolytic rancidity is the result of moisture in the oil; whereas oxidative rancidity is due to oxygen reaction with the unsaturated fatty acids. Naturally some antioxidants (like vitamins E) are present in vegetable oils to retard the rancidity. Hydrogenation is the conversion process of oil into fat to increase their melting point; the process of conversion is in the presence of catalyst (Nickel) e.g. vanaspati. This process converts the unsaturated fatty acids to saturated fatty acids and also converts the cis forms of unsaturated fatty acids to trans forms of unsaturated fatty acid. The latter are harmful for the heart. Animal fats contain Vitamin A & D, where as Vitamin. E is present in vegetable oils.

Functions

a) Is a concentrated source of energy providing 9kcal/g.;
b) Provides palatability to diet;
c) They are building blocks for synthesis of biologically important lipids such as phospholipids, sphingolipids and cholesterol esters having many metabolic regulatory roles.
d) Helps in absorption of fat-soluble vitamins.
e) Essential fatty acids (EFA) are important for the function and structure of body cells membranes, for hormones like prostaglandin, for specific function of CNS and vision. They can't be synthesized by the body and are available from vegetable sources. The two essential fatty acid linoleic acid (LA-n6) and alpha-linolenic acid (ALA-n3) are important for body.
f) Numbers of studies have suggested the beneficial effect of monounsaturated fatty acids (MUFA) such as lowering risk of coronary heart disease, cancer, cataract, and other inflammatory disorders.
g) Fats as adipose tissue act as an insulator and padding for vital organs.
e) The different fats and oils having varied physical properties due to different number of triglycerides present, affects its melting point, thus affecting their use in various food manufacturing application of cake, mayonnaise, ice cream etc.

Deficiency

The essential fatty acid deficiency known as phrynoderma is seen along with malnutrition.

Recommended Dietary Allowance

A minimum amount of fat is required to meet the requirement of essential fatty acids. As per the American Heart Association guidelines 20% or less of total energy from fats is recommended.

Fat from varied sources is preferred than from any single kind. Saturated fatty acids should provide 8-10% of total caloric intake, polyunsaturated fatty acids should provide 5-8% & monounsaturated fatty acid should provide 3-7% of total calories intake.

In an Indian diet, it is recommended to use either groundnut, rice bran, seasame or sunflower, corn, cottonseed oil along with palm oil or any other oils mixed with mustard or soybean oil.

Dietary sources

Fat is present in food as visible or invisible form. It is present in small percentage in cereals and legumes as invisible form. Butter, vanaspati etc from animal sources and oils (e.g. groundnut, mustard, coconut, safflower etc) from vegetable sources are the visible sources.

Proteins

Protein is also one of the major macronutrients. It contains carbon, hydrogen, oxygen and nitrogen. Some proteins also contain sulpher and phosphorus. The basic structure or building unit of protein is amino acid. It has an amino group-NH_2 and carboxyl group-COOH. The amino acids are joined by peptide linkages to form protein. Amino acids are water soluble, crystalline and insoluble in organic solvents.

Classification

There are about 20 amino acids present in the body. Nine amino acids are essential for humans, as humans cannot synthesize them. These are isoleucine, leucine, lysine, methionine, phenylalanine, threonine, trytophan, valine and histidine. Infants require two more essential amino acids (arginine and histidine). The nonessential amino acids are glycine, alanine, serine, cysteine, cystine, aspartic acid, glutamic acid, arginine, hydroxylysine, tyrosine, proline, and hydroxyproline. There are two types of proteins- animal and vegetable protein. Examples of

animal proteins are milk, meat, egg, etc. These are better digested and absorbed than the vegetable protein sources (dals & legumes) as the essential amino acids present are similar to those present in the tissues of the body. Animal proteins are completely utilized for tissue synthesis. Vegetable proteins are relatively low in or lack lysine, methionine and tryptophan.

Metabolism

Digestion of protein starts from stomach and finally completes in small intestine. Proteins on hydrolysis break down to polypeptides and finally into amino acids. The amount as well as the type of protein taken in diet is equally important as the digestibility and absorbability vary between different proteins.

Biological Value (BV) of proteins is defined as, "the percentage of absorbed protein nitrogen that is retained in the body". A high BV thus indicates a high degree of utilization of the amino acids of the protein. Animal protein foods have higher BV as compared to vegetable protein foods. Net Protein Utilization (NPU) is defined as, "the percentage of protein eaten that is retained.

Functions

It is the most important constituent of food since it is

1. Required for general growth, maintenance & repair of body tissues.
2. Secondary role as energy source.
3. Essential for synthesis of protoplasm, enzymes e.g. globular proteins and hormones.
4. For production and maintenance of body proteins
5. Required for the supply of the essential amino acids which cannot be synthesized in the body

Deficiency

Low protein diets in experimental animals cause anemia, hypoalbuminemia and edema. Infants with improper weaning and fed on low protein diets suffer from physical and mental retardation along with anemia, hypoprotenemia, cheilosis, stomatitis, conjunctivitis edema and fatty liver. This is known as 'kwashiorkor'. These infants are frequently prone to infection and the mortality is high in such untreated children. Protein deficiency is generally observed with calorie deficiency and this condition is called 'protein calorie malnutrition'. Some studies have suggested that deficiency or imbalance of essential amino acids in the diet may produce profound depression of immune responses.

Recommended Dietary Allowance

For maintenance of nitrogen balance, the minimum protein requirement is 0.51-0.66g (av. 0.57g) per kg body weight. ICMR has recommended an allowance of 1.0 g per Kg for adults to provide 0.57g protein as an Indian vegetarian diet has a lower biological value of about 60 (net utilization of vegetable protein will be about 65% only. The requirement for infants and children is 1.5-2.0g/Kg. During pregnancy and lactation an additional 10-20g-protein is recommended. It has been recommended that the diet should have at least 1/3 to ½ of total proteins from animal sources.

Dietary Sources

Protein rich foods are widely present in nature; from animal and vegetable sources. Animal sources are liver, meat, egg & milk and the vegetable sources include legumes, soybean and nuts.

Fig. 2: Some Protein Sources- soybeans, nuts, fish

Water

Water is essential for every living organism,. In the human body, water content ranges from 50-70% in different tissues. It is present in different fluid compartments of the human body- Intracellular (fluid inside the cells) and extra cellular. Plasma, interstitial fluid, cerebro-spinal fluid, ocular fluid, lymph, peritoneal, pericardial, pleural and synovial fluids are part of the extra cellular fluid.

In infants, the body has a higher percentage of water (80%) with a higher percentage (20%) of extra cellular fluid. Thus it is essential to carefully maintain the infant's intake and output. Any disturbance causing changes in the extra cellular fluid could lead to dehydration.

Dehydration

Due to deprivation of water, there is concentration in plasma, in extra cellular and intracellular compartments. In case of rapid deprivation (of about 20%) of body water, death may occur; especially in children with diarrhea. This can be prevented by administering oral rehydration therapy. The oral rehydration solution (ORS) consists of Sodium chloride-3.5g; Potassium chloride-1.5g; trisodium citrate/ sodium bicarbonate-2.9g and glucose –20g in a litre of water.

Control mechanism

By regulating fluid input and output, the body water is fairly maintained .The mechanism of thirst regulates water intake. The 'thirst centre' is located in the 3rd ventricle of the brain regulating the water consumption. When there is concentration of body fluids (with respect to the solutes) due to decrease in water intake; it leads to a rise in the osmotic pressure. This causes drawing out of water from the intracellular compartment. This cell dehydration stimulates the osmorecepters and the sensory nerves of mouth & pharynx.

On the other hand, the osmotic pressure lowers, when more water is in the fluid compartment. This initiates release of antidiuretic hormone by posterior pituitary and decrease in reabsorbtion of water by distal convoluted tubule in the kidneys.

Vitamins

Vitamins are organic compounds. Although they are required in small amounts, but are essential for many important functions of the body. They can not be synthesized by the body. Due to shortage of specific vitamins various deficiency diseases could occur. The vitamins were designated by letters A, B and so on before their structures were determined. Foods contain small quantities of these vitamins.

Fig. 3: Vitamin Sources - Fruits and Vegetables

Classification

They are categorized into two groups- fat soluble vitamins-Vitamin A, D, E, K and water fat soluble vitamins-several B Vitamins and vitamin C.

Fat soluble Vitamins

Vitamin A or Retinol

Vitamin A is the general term used for several chemically related compounds such as retinol, retinaldehyde, retinoic acid and retinyl esters. Out of these retinol is the major natural occurring form (Vitamin A alcohol). Retinol is a pale yellow solid, which dissolves freely in oils and fats and is slightly soluble in water. It is relatively heat and alkali stable and unstable in light and to acid. It is found in fatty parts of foods especially animal foods. Retinol is a complex unsaturated alcohol of molecular formula $C_{20}H_{29}OH$. In animal tissues it is stored and transported as an ester formed with a long-chain fatty acid.

Metabolism

Vegetables contain no retinol. They have yellow pigments called carotenes, chemically related to vitamin A. Carotenes can be converted to retinol in the wall of the small intestine during absorption. Several carotenes are known; but the most important is beta-carotene, which is often referred to as ‘provitamin A’. The molecule of beta-carotene is almost exactly twice as big as

that of vitamin A. It is an unsaturated hydrocarbon, not an alcohol. In the body, conversion of beta- carotene to retinol is less that is yields only 50% retinol. In addition, carotenes from vegetable food are not completely absorbed and the availability is 25-50 % depending on the diet and fat content in the diet. Thus based on the absorption and physiological conversion, a unit of beta carotene yields only 0.25 units of retinol in the body. . Retinol and carotenes are highly unsaturated and get easily destroyed by oxidation especially at high temperatures. As they are insoluble in water, there is no loss by extraction during boiling of vegetables. As retinol is not soluble in water the excess is accumulated in the liver, but excessive intake is to be avoided and may prove to be injurious.

Functions

1. Retinol has an important function in the visual process; necessary for vision in dim light.
2. Is necessary for maintaining the integrity of healthy epithelium especially the membrane line of eyes, mouth, gastrointestinal, respiratory and genitourinary tract.
3. Is required for normal skeletal growth and tooth development.
4. Vitamin A also facilitates other functions such as for reproductive cycle, in iron metabolism.
5. Beta-carotene is a powerful antioxidant. It helps to protect the easily oxidized nutrients, such as PUFAs, from oxidation. It is also able to protest the body from the harmful effects of the free radicals in the body.

Deficiency

One of the earliest signs of vitamin A deficiency is known as 'night blindness'-a condition when it is difficult to see in dim light. It is caused by shortage of retinol derivative called 'rhodopsin'. Vitamin A is essential for the maintenance of healthy skin and mucous membranes. Long-term deficiency causes dead cells to accumulate on surface of eye making it dry and opaque (xeropthalmia). In case of infection and ulceration of cornea (keratomalacia) and may lead to blindness. This is a major public health problem in our country.

In severe vitamin A deficiency, epithelial changes, skin changes, degeneration of cells, with increase susceptibility to infection (eye, nasal passage, sinuses, middle ear, lungs and genitourinary tract) may occur.

Treatment and prevention of vitamin A deficiency

For children below 6 years of age prophylactic dose of 50,000 international units is recommended. A daily oral dose of 10,000 international units vitamin A is advised in case of mild to moderate deficiency cases and 50,000 international units vitamin a for a week for severe cases.

Recommended Dietary Allowance

In a mixed Indian diet a conversion factor of 0.25 is required to calculate the retinol from beta – carotene in food. The daily requirement for adult man & women is 600ug; with an increase of 350ug for lactating women.

Dietary Sources

Retinol is found in animal tissues (liver, egg yolk) and dairy products (whole milk, butter, cheese). Fish liver oils are the richest source. Carotenes are found in plant tissues such as dark green vegetables (spinach, turnip leaves, beet greens, bathua etc.) and yellow fruits and vegetables (carrot, pumpkin, papaya, mango etc.) are good sources of carotene. Crude palm oil is also rich source of carotene.

Fig. 4: Retinol/ carotene sources- liver oil capsules, dark green vegetables and yellow fruits and vegetables

Toxicity

Large intake (therapeutic dose) of vitamin A for long periods would lead to hypervitaminosis with symptoms such as nausea, headache, vomiting etc.

Vitamin E or Tocopherols

Vitamin E is a term used for tocopherols and tocotrienols and their derivatives. It is light yellow oil ($C_{29}H_{50}O_2$), stable to high heat and acid but decomposition occurs in UV light. Oxidation occurs in presence of rancid acid, lead and iron salts. In nature, four tocopherols and four tocotrienols occur, the difference being the number and the position of methyl groups on the chromanol ring. In addition several types of synthetic Vitamin E are available.

Function

The principal role of vitamin E is as an antioxidant, though the exact mechanism is not yet known. Various other functions are as follows:

a) Regulation of immune response through cell mediated immunity.
b) Protects from various diseases like cancer, arthritis and ischaemic heart disease by preventing peroxidation and maintaining integrity of cellular membrane.
c) Prevents oxidation of beta carotene, vitamin A and vitamin C. Prevents lipid peroxidation of polyunsaturated fatty acids(PUFA) in cells.
d) In rats, Vitamin E affects the reproductive biology. But no such definitive role has been observed in human subjects.
e) The vitamin derivative is found to be necessary for Coenzyme Q synthesis.
f) They are used in the food industry as antioxidants and permitted food additives.

Deficiency

It is rarely observed in humans. It may be observed in subjects with either fat malabsorption or subjects on total parenteral nutrition (TPN) or in premature infants fed on formula feeds.

Recommended Dietary Allowance

The requirement is related to the fat and poly-unsaturated fatty acid (PUFA) content of the diet. For Indians, the requirement has been suggested to be as 0.8mg/g of essential fatty acids.

Dietary sources

Most of the cereal germ oils like wheat germ oil, corn oil and cottonseed oil, are good sources.

Fig. 5: Corn oil

Toxicity and Therapeutic Doses

No hypervitaminosis is reported. Benefits of daily doses (400-800mg/day) for different conditions such as sterility, ischemic heart disease, muscular dystrophy and diabetes mellitus have not yet been established in clinical trials. It is therefore suggested that excessive ingestion of vitamin E for long periods should be avoided as some authors have reported adverse effects like impaired blood coagulation, reduction in thyroid hormones and elevation of lipids.

Vitamin D or Cholecalciferol

Cholecalciferol (Vitamin D3) is the naturally occurring form on animal cells. It is obtained endogenously, by the action of ultraviolet light on 7-dehydrocholesterolin the skin to form Vitamin D3 (Cholecalciferol). Ergocalciferol (Vitamin D2) is found in plants, and is produced when ergosterol is exposed to ultraviolet light. Dietary Vitamin D2is ergocalciferol- the major source being fish, and some fortified margarines. Vitamin D is white crystalline solid, freely soluble in oils and fats. Vitamin d is stored in the liver.

Metabolism

Both vitamin D2 & vitamin D3 undergo similar metabolic changes in the body. In the food dietary Vitamin D is absorbed along with fats from the jejunum and ileum. For effective absorption, bile is essential. It is transported in the chylomicrons through the lymph circulation. Vitamin D produced in the skin enters the blood and circulates attached to specific globulin. In most individuals the endogenous synthesis is the major source of vitamin D.

Cholecalciferol is hydroxylated first in the liver to 25-hydroxy cholecalciferol (25-OH-D3) and then in the kidney to 1, 25 dihydroxy cholecalciferol (1-25-OH-D3). With the help of specific binding proteins , these metabolites are transported in circulation and is an important hormone for calcium homeostasis and its actions.

Function

1) Necessary for absorption of calcium and phosphorus by the body.
2) These minerals (calcium and phosphorus) are needed for formation of bones and teeth.

Deficiency

Deficiency leads to inadequate absorption of calcium and phosphorus and further faulty mineralization of bone and tooth structures. Decreased synthesis or dietary deficiency causes rickets in children and osteomalacia in adults. Low serum calcium also causes tetany.

Recommended Dietary Allowance

By exposure to sunlight adequate Vitamin D can be synthesized in the body. Therapeutic supplementation is necessary (10µg) in case of deficiency due to metabolic or genetic reasons.

Dietary Sources

Good sources of vitamin D are exposure to sunlight, fish liver oil. Other animal foods such as egg yolk, liver, and fish like herring, tuna, and sardines have small amounts of Vitamin D..

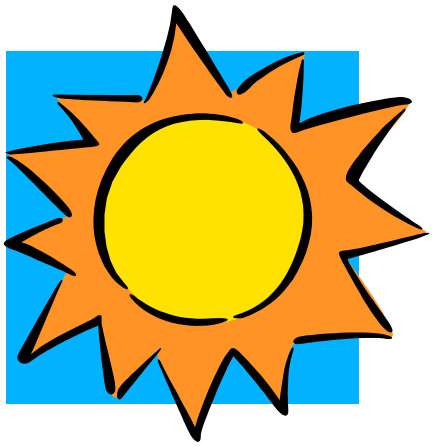


Fig. 6: Vitamin D Source - Sunlight

Toxicity

Excessive amounts of Vitamin D could lead to hypocalcaemia. Thus intake should not exceed a total of 400international Units daily. Toxicity symptoms may include nausea, vomiting, diarrhea.

Vitamin K or Naphthaquinones

Vitamin comprises of compounds derived from menadione (2 methyl-1, 4 naphthaquinone). It exists in two forms in nature; vitamin K_1- phylloquinone or phytlmenaquinone and K_2 - menaquinone or multiprenylmenoquinone. K_1 is present in various green leafy vegetables like spinach and K_2 in gastrointestinal tract of human and some animals as it can be synthesized in bowel by microorganism. These both are fat soluble, heat stable vitamin, but are unstable to strong acid, alkali, sunlight and oxidation.

Metabolism

In the presence of bite salts Vitamin K is readily absorbed along with fats in the upper small intestine and is transported to liver in the chylomicrons.

Function

- The main function is in the formation of a number of coagulation factors like prothrombin factor II, VII, IX and X.
- Some studies have suggested the role of vitamin K and D on bone mineral density/ bone health.

Deficiency

The dietary deficiency is usually unlikely, but the deficiency may occur due to interference with the absorption or synthesis. The deficiency leads to an increase in the prothrombin time and thus an increase risk of hemorrhage.

Recommended Dietary Allowance

Due to the variation in intestinal synthesis, no dietary allowances have been recommended. Still 'safe intake' advised for adults is 1-2 µg/kg Body Weight/day and 10µg/day for infants.

Dietary sources

Green leafy vegetables are good sources of vitamins K, though the absorption is relatively poor as it is bound to membrane of the chloroplasts. Some plant derived oils such as Soya and Canola oils are also rich in vitamin K. Further research is still required to find the bioavailability and bioactivity of Vitamin K form in different food sources.

Fig. 7: Green Leafy Vegetable

Toxicity

No documentation of vitamins K toxicity has been reported.

Water-soluble B group Vitamins

These groups of vitamins are important in the metabolism of carbohydrates, proteins and fats. Thiamine is referred to as B_1 and the other B_2 include riboflavin, nicotinic acid, pantothenic acid, pyridoxine, folic acid, Vitamin B_{12}, biotin, choline and inositol. In human nutrition, the first seven (of B_2 Vitamin) are of importance whereas the last two are important in nutrition of animal, poultry and microbes

Thiamine /Vitamin B_1

The thiamine molecule has an amino and a hydroxyl group. Thiamin hydrochloride is water soluble, heat labile white crystalline substance. It is destroyed by heat in neutral and alkaline solutions but is resistant to heat in acids solutions.

Metabolism

In food thiamin is available either in the free form or bound as thiamin pyrophosphate or bound with protein. Mainly the absorption takes place in the duodenum. It is not stored by the body, hence an adequate and regular supply is required.

Function

- The principle active form is thiamin pyrophosphate (TPP). It acts as a co-enzyme in the carboxylation and transamination reactions in carbohydrate, protein and fat metabolism.
- Is essential for a number of important enzyme systems used for release of energy from food.
- It affects the function of nerve cell membranes.

Deficiency

Thiamin deficiency known as beriberi may occur either due to poor dietary intake (use of highly milled cereals only)or due to gastrointestinal disturbances like vomiting, diarrhea etc. Two deficiency forms termed as ‘Dry’ and ‘Wet’ Beri Beri are seen in adults. The deficiency in infants is called ‘infantile Beri Beri’. The deficiency symptoms are loss of appetite, muscular weakness, peripheral neuritis (Dry Beri Beri); fatigues, dizziness, breathlessness, enlargement of heart, heart failure (Wet Beri Beri).

It has been observed that various vitamins B deficiencies overlap. Hence a mixture of B-complex is given in deficient states. Only in specific deficiency, a single large dose of vitamins is advised.

Recommended Dietary Allowances

The requirement is based on the total energy requirement, composition of diet and cooking losses. The Recommended Dietary Allowances is 0.5 mg thiamin per 1000 kcal of diet.

Dietary sources

The richest sources of thiamin are Wheat germ and Brewer's yeast. Dry beans, peas, soybeans, peanuts and egg yolk and liver are also good sources. Unmilled cereals and pulses contain high amount of thiamin whereas highly polished cereals like rice are poor source of thiamin.

Fig. 8: Wheat, Soybean

Retention of food value

Thiamin being water soluble, it is observed that considerable losses occur if water is thrown in which food is cooked. The losses are reduced if the amount of cooking water and total cooking time is reduced. Edible soda / making the cooking medium alkaline should be avoided. 25% of thiamin loss is observed during roasting of foods.

Riboflavin

Riboflavin molecule is a heterocyclic ring of carbon and nitrogen atoms. It is an odorless, orange yellow, bitter tasting compound, sparingly soluble in water. It is resistant to heat, oxidizing agents and acids. It is sensitive to light.

Metabolism

It is absorbed in the small intestine.

Functions

- It is a component of two major coenzymes Riboflavin Mononucleotide (FMN) and Flavin Adenine Dinucleotide (FAD) that are part of Krebs' energy cycle reactions.
- It is also a constituent of enzymes and amino acid oxidases required for oxidation of purines and amino acids.

Deficiency

Riboflavin deficiency (Ariboflavinosis) has symptoms of glossitis (soreness of tongue) dermatitis (especially in scrotal regions and seborrheic dermatitis), chielosis (cracking of lips), angular stomatitis and increased sensitivity of the eyes to light, itching and soreness of eyes. Riboflavin deficiency is highly prevalent especially among children and women in India.

Recommended dietary allowances

Riboflavin has a major role in the energy cycles reactions, thus the requirements are based on the total energy requirements and basal metabolic rate. Keeping in view, the high cooking losses an intake of 0.6 mg riboflavin per 1000 kcal is recommended for adults.

Dietary sources

It is widely distributed in various foods with highest concentration in liver, dried yeast, skimmed milk powder. Other good sources are green leafy vegetables, fresh milk, eggs, meat, and fish. Millets and legumes are fair sources. Milled cereals and its products, other vegetables, roots and tubers are average sources of riboflavin.

Fig 9: Milk and Green leafy Vegetable

Losses during cooking

There is not much loss in usual cooking process as riboflavin is sparingly soluble is water. But addition of soda to vegetables; pasteurization, evaporation and drying of milk; stewing, roasting of meat causes some riboflavin losses in the range of 10-25%.

Niacin (Nicotinic acid)

Niacin is present in two forms- a pyridine carboxylic acid nicotinic acid and its amide nicotinamide (niacinamide). These are water soluble and resistant to acids, bases, light or heat.
Metabolism: The absorption takes places in the small intestine. In humans and animals, tryptophan from the diet can be converted to niacin (60 mg of tryptophan=1 mg niacin).

Functions

- It is a part of coenzymes nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP) which are part of krebs cycles, fatty acids and cholesterol metabolism.
- It is required for conversion of phenylalanine to tyrosine.

Deficiency

Niacin deficiency results in pellagra- a condition involving gastrointestinal tract, nervous system, and skin. It is characterized by classical three D's- dermatitis, diarrhea, and dementia. Deficiency is observed in exclusive maize eating population as in Mexico and jowar eating population of southern India. It is due to bound form of nicotinic acid and due to imbalance of amino acids present.

Recommended dietary allowances

6.6 mg niacin equivalent per 1000 kcal has been recommended for all ages. The total niacin content expressed as niacin equivalents (mg) = niacin content + 1/60 tryptophan content. For assessing the requirement, both niacin and tryptophan contribution is considered.

Dietary sources

The best sources are animal products like kidney, tuna fish, liver and brewer's yeast. Other animal foods like meat and poultry and vegetable sources like whole cereals, pulses, nuts (especially groundnut) are good sources. Milk, though low in niacin is a rich source of tryptophan.

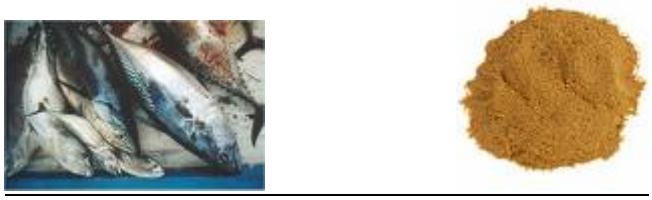


Fig. 10: Fish and Brewer's Yeast

Losses during cooking and processing may occur during boiling, as the vitamin is water-soluble. Reducing the amount of cooking water could reduce loss.

Pyridoxine (Vitamins B_6)

Name represents group of three pyridine derivatives. In animal products, it is present as pyridoxal and pyridoxamine; in vegetable products, it is present as pyridoxine. They are all interchangeable in the body.

Metabolism

Similar to other B-vitamins, it is absorbed in the small intestine and not stored in the body Pyridoxal phosphate is the active form of vitamin B_6.

Function

- It acts as a co-enzyme in the amino acids metabolism, catalyzes conversion of tryptophan to niacin, required for glycogen breakdown
- Required for formation of antibodies, synthesis of hemoglobin molecule
- Required in important chemical reactions in nervous system.

Deficiency

Some of the symptoms of vitamin B_6 deficiency observed are anemia, skin lesion, glossitis, cheilosis, and seizures and reduced antibody production. However it is rarely observed as it is present in number of foods. Pellagra is also known to develop in tuberculosis patients receiving isoniazid medication as this depletes the coenzyme required for conversion of tryptophan to NAD.

Recommended dietary allowances

Though the requirements for Indians have not been established, an average dietary recommendation for adults is 1.5mg/day.

Dietary sources

It is present in a number of food products such as dried yeast, wheat germ, whole cereals, legumes, oil seeds, nuts, milk, egg, meat, liver, fish and green leafy vegetables.

Pantothenic acid

It is pale yellow oil with structure-$OHCH_2C(CH_3)_2CHOHCONHCH_2CH_2COOH$. It is soluble in water, destroyed by acid, alkali and heating.

Metabolism

It is absorbed in the gastrointestinal tract by intestinal cells and enters the circulation.

Function

- It is part of two important coenzymes- Co A (coenzymes A) and ACP (Acyl carrier protein) which are part of the carbohydrate and fat metabolism.

Deficiency

On being fed with antagonist various deficiency symptoms may occur such as loss of appetite, abdominal pain, peripheral neuritis, fatigue, weakness, insomnia and respiratory infections .

Recommended dietary allowances

The safe and adequate daily intake of 4-7 mg for adults has been recommended.

Dietary sources

It is present in number of plant and animal tissues. Animal sources like liver, yeast; egg yolk and meat are good sources of pantothenic acid.

The vitamin loss during milling and dry processing is about 50%.

Biotin

It is a cyclic urea derivative, stable to heat, light and acids. It is usually combined with proteins in the food and in tissues.

Metabolism

The dietary vitamin is absorbed by the intestinal cells. In addition, intestinal bacteria produce biotin in the gastrointestinal tract.

Function

- It acts as a coenzyme in the synthesis of fatty acids and purines.

Deficiency

Due to its wide food availability, deficiency is rare.

Recommended dietary allowances

The recommended dietary allowance has not been established. The safe estimated intake for adults is 100-200mg/day.

Dietary Sources

Nuts and legumes, organ meats & egg yolk are good sources.

Cobalamin/ Vitamin B_{12}

Vitamin B_{12} is a large molecule ($C_{63}H_{90}O_{14}N_{14}PCo$) having cobalt as part of its structure. It is a deep red crystalline substance. It is stable to heat and only slightly soluble in water. When in the form of a solution, it is destroyed by sunlight.

Metabolism

Vitamin B_{12}, is absorbed in the small intestine requiring an intrinsic factor secreted by the stomach and is transported in blood circulation bound to a protein.

Functions

- It forms part of coenzymes of some important metabolic reactions like synthesis of DNA, methionine and choline,
- For the metabolism of folic acid,
- Along with folate and iron , required for formation of red blood cells,
- Required for maturation of cells,
- Involved in formation of mylelin sheath surrounding the nerve fiber.

Deficiency

The deficiency results in a condition called pernicious anemia. The mature red blood cells (RBC) are not produced by the bone marrow and thus the capacity to carry oxygen by the hemoglobin is reduced. Dietary deficiency is usually observed in persons who do not consume any animal food. In addition, the deficiency is also seen in persons to lacking intrinsic factor, which is required for absorption. This is observed in cases of malabsorption syndrome and in cases of surgical removal of part of the stomach.

Recommended dietary allowances

It is required by the body in minute amounts. The daily allowance of 1 μg/day has been recommended for adults.

Dietary sources

Vitamin B_{12} is present only in animal foods (e.g. liver, meat, fish, kidney, brain & egg) and is not present in foods of vegetable origin. Bacteria in the gastrointestinal tract also synthesize Vitamin B_{12}.

Folic acid

The generic name for folic acid is Folacin. It is a yellow crystalline substance, slightly soluble in water and stable in heat at neutral pH.

Metabolism

The absorption is mainly from the small intestine is mainly stored in the liver.

Function

- Along with vitamin B_{12}, it is essential for DNA synthesize and for RBC's formation.
- It has been observed that if folate supplementations are given before preconception, the incidence of neural tube defects is reduced.
- It has been recently recognized that chronic mild hyperhomocysteinemia is a major risk factor for vascular disease and these respond to increased folate intake. It is yet to be confirmed if higher folate intake has a positive effect on vascular disease incidence.

Deficiency

The deficiency of folic acid cause megaloblastic or macrocytic anemia, resulting from inadequate dietary intake or secondary to diseases like malabsorption syndromes or during pregnancy when the high requirements are not met with. The symptoms of this anemia are- reduction in number of RBC's, immature large nucleated cells, low hemoglobin, low leukocyte and platelet levels. Medicinal supplements are recommended in such cases.

Recommended dietary allowances

Based on various studies, the recommended dietary allowances has been fixed at 100 mg/day for adults, with an additional intake of 300 mg for pregnant women and 50 mg for lactating women.

Dietary sources

It is present in a number of both animal and plant food stuffs like liver, kidney, yeast and deep green leafy vegetables and pulses.

Toxicity

No folate toxicity has been reported on high folate intake.

Ascorbic Acid or Vitamin C

Ascorbic acid or vitamin c is a water soluble white crystalline compound ($C_6H_8O_6$). The molecule does not contain a free carboxyl group and is a lactone. Lactones behave like acids. Ascorbic acid has a sharp taste usually associated with acids and will form salts. It is optically active and is dextrorotatry. It is a good strong reducing agent and gets easily oxidized. It is one of the unstable nutrients and is easily destroyed by atmospheric oxidation, exposure to light or high temperatures, alkalinity and metal ions especially copper. The rate of oxidation is reduced in weak acid solution and at low temperatures.

Metabolism

The vitamin is rapidly absorbed from gastrointestinal tract, with very little storage. As humans lack the enzymes required for its synthesis, it has to be provided in diet.

Functions

- Ascorbic acid is easily oxidized. It is able to protect other substances from oxidation; acting as an antioxidant. Synthetic ascorbic acid & its sodium and calcium salts are used as permitted antioxidants in food industry.
- In body tissues, ascorbic acid protects the easily oxidizable nutrients. It is effective in 'mopping up' free radicals. It has a preventive function for diseases in which free radicals are involved.
- It helps in absorption of dietary iron
- Is involved in collagen (intercellular connecting protein) synthesis, formation of bone and teeth calcification & many other reactions.

Deficiency

Vitamin deficiency results in a condition called scurvy-characterized by weakness, bleeding gums and defective bone growth.

Recommended Dietary Allowances

The recommended dietary allowance is 40mg/day for adults; 25mg/day for infants and 80 mg/ day for lactating women.

Sources

Ascorbic acid occurs in mainly in foods of plant origin, especially fruits and vegetables. Fresh green vegetables and salad vegetables like cabbage, lettuce, spinach, amaranth and cucumber

contain this vitamin. The citrus fruits (lemons and oranges), berries and melons are particularly rich in the vitamin. Tomatoes and potatoes also contain good amount. Gooseberry (Amla) is one of the richest sources of this vitamin. Storage causes decrease in the vitamin C content. Germinated grains have a higher vitamin C than nonsprouted cereal and legumes.e.g. Sprouted green gram. Amongst fruits, gooseberry (amla) and Guava are very rich sources of vitamin C.

During cooking, around 75% of ascorbic acid is lost. It is advised that a minimum amount of water should be used for cooking vegetable. It is best to place the vegetables in boiling water as this contains no dissolved oxygen. Addition of soda bicarbonate (alkaline condition) should be avoided. Heating or drying leads to Vitamin C destruction but gooseberry (Amla) is an exception.

Fig. 11: Ascorbic acid sources- Fruits, vegetables and sprouts

Minerals

Minerals are required for many purposes like forming the frame and rigid structure of the body, as part of the body/cell fluids and for number of cellular and sub cellular physiological functions.

Calcium

Most of the calcium in the body is present in the bones and teeth; only a small amount (1%) is present in blood/body fluids. It is present either is combination with protein or as calcium ion. Thyroid and parathyroid hormones maintain the concentration of calcium in blood. During dietary deficiency, the calcium present in the bones maintains the blood calcium levels.

Metabolism

The dietary calcium absorption is only 20-30%. The dietary absorption depends on many factors e.g. vitamin D levels, any renal insufficiency, hypothyroidism and interaction with other diet components like phytates (present in cereals) and oxalates (present in amaranth, horse gram, gingelly seeds, tea coffee). The availability of calcium is reduced as it binds to form insoluble calcium phytate/oxalate. The calcium absorption across the intestinal mucosa is by both active and passive transport.

Function

- Calcium is required for blood clotting;
- for contraction of the muscles (e.g. contraction of heart) and
- For many enzymatic activities.

Deficiency

Calcium loss leads to a condition is known as osteoporosis. In this condition, due to loss of calcium, bone becomes fragile and brittle and fracture easily. This is often found in postmenopausal women. Achievement of high bone mass through good nutrition and exercise during period of growth is beneficial.

Recommended Dietary Allowances

The requirement varies based on the age, sex and physiological conditions (e.g. growing children, pregnancy or lactating women). It varies from 400-1000mg per day. If dietary calcium sources are insufficient, the calcium required is taken from bones.

Dietary Sources

Calcium is present in both the plant and animal foods. Foods of animal sources are milk and fish (bhekti, chingri, rohu etc). Among vegetable sources, green leafy vegetables like amaranth, drumstick and fenugreek leaves are the richest sources of calcium. Amongst cereals/millets and pulses, ragi (millet); soybean and rajmah have high calcium content than other cereals & pulses. Nuts (almonds) and oilseeds (gingelly & mustard seeds) are also good calcium sources.

Fig. 12: Calcium sources- Fish, Green Leafy Vegetable and Milk

Iron

It is the major component of pigment hemoglobin in red blood cells, (which is essential for the transportation of oxygen; accounting for approximately 0.1% mineral content in the body. Iron, to a smaller extent, is also present in muscle as myoglobin (muscle protein) and as cell enzymes (cytochromes). Rest is stored in the liver, spleen and bone marrow (as iron binding protein-ferritin and haemosiderin).

Metabolism

The absorption of dietary iron by the body is small. Many factors affect rate of absorption-such as source of iron, presence of vitamin C in the diet. The bioavailability of iron varies depending on the kind of diets i.e. iron present in animal products (haem iron) is more readily absorbed than non-haem iron present in plants. Presence of ascorbic acid in the diet also promotes absorption (it reduces ferric ion to the absorbable ferrous state).

Function

Iron is a major component of pigment hemoglobin in red blood cells

Deficiency

With a prolonged iron deficiency, the hemoglobin falls below normal and the condition is known as anaemia. Iron deficiency anemia is an important nutritional problem in our country. It is observed that women especially pregnant women (60-70%) and children are suffering from iron deficiency anemia. Different factors contribute to it -poor iron absorption from our diets, various worm infestations and blood losses. For prevention and correction of anemia, haematinics (medicinal iron) are provided especially to pregnant women for their high requirements.

Recommended Dietary Allowances

Due to the low absorption rate of iron from composite cereal based diet (approximately2-5% only); the recommendations for daily allowance is 28-38mg for adults.

Dietary Sources

Green leafy vegetables (amaranth, colocasia leaves, mustard leaves, pulses like soybean lentil, cow pea, roasted Bengal gram, cereals and millets (bajra, rice flakes) are rich sources of iron. Among animal products, liver is a rich dietary source.

Fig. 13: Green Leafy Vegetable

Iodine

It is the heaviest member of the halogen group, occurring as salts in nature especially in seawater. The body has approximately 20-50mg iodine.

Metabolism

It is present as iodide in blood and is absorbed in the thyroid gland (as hormones thyroxin and tri-iodothyronine).

Function

Thyroxin and tri-iodothyronine are important hormones for

- Body's metabolic activity,
- Energy production in cells.

Deficiency

Iodine deficiency disorder (IDD) is a major public health problem in our country. If dietary deficiency occurs, the thyroid gland increases in size to compensate for the deficiency (known as goiter). Goitre occurs in many parts of the world especially in areas where iodine level of soil are low. This affects the level of the iodine in vegetation. Some vegetables if consumed in large quantities especially cabbage and cauliflower of brassica family interferes with the uptake of iodine by the thyroid gland thus causing goitre.

Iodine deficiency during the pregnancy affects the fetus and may lead to mental and growth retardation in later life. One of the ways of controlling IDD is the use of 'iodized salt'. This is prepared by adding potassium iodide (30ppm) to the salt.

Recommended Dietary Allowances

The daily requirement is reported to be 0.15mg.

Dietary Sources

Sea foods are the richest sources-like cod, salmon herring, and cod liver oil. Some iodine is also found in drinking water.

Basic food groups

There is no single food providing all essential nutrients in sufficient amounts. Different foods provide different nutrients, requiring us to select a variety of foods so as to provide a balanced satisfactory diet. Quantitatively and qualitatively; the kind of diet/food we consume is important for our health and well being. Conveniently, foods are grouped as -

1. Cereals, Millets and pulses
2. Vegetables and fruits
3. Milk and milk products, egg, meat and fish
4. Oils & fats and nuts & oilseeds

They are also classified according to their functions-

1. Energy Foods -Carbohydrate and fat rich foods mainly contribute energy in our diet. The carbohydrate rich foods are cereals, sugars, and starchy vegetables. The fat rich foods are oils, nuts and butter etc. In addition to energy, cereals also provide B-group of vitamins and several minerals. The fats and sugars add palatability to the diet.

2. Body Building Foods- Body building foods are mainly protein rich foods such as milk & its products, egg, meat, fish, poultry (animal sources); pulses, legumes and nuts (plant sources). In addition, these foods contribute Vitamin A, Vitamin B, minerals and energy. The animal proteins contain all essential amino acids and have better protein utilization than plant proteins.
3. Protective Foods -This group of food consists of mainly of vitamin and mineral rich food sources such as fruits and vegetables (except roots and tubers). Among various fruits and vegetables, orange and deep yellow colored fruits and vegetables are good source of β-carotene; green leafy vegetables are rich in calcium, iron, vitamin C and β -carotene; and citrus fruits are good source of vitamin C.

While selecting food it is also useful to able to compare the nutrient value. One of the simplest ways is through nutrient density. Nutrient density is the amount of nutrient present in relation to a unit of energy. Use of nutrient density concept is helpful in providing high nutrient with smaller size portions in different situations such as requirement as in children & elderly.

Earlier nutrition science has focused on understanding deficiencies thus recommendations were given. Further step was epidemiologic studies showing how diet contributes to risk of certain diseases e.g. fat and cardio vascular disease. The increasing knowledge about micronutrients including vitamins , minerals and other compounds(such as flavones, anthocyans) on a molecular level together with results from epidemiological studies open a new field of nutrition science-neutriceuticals- link between nutrition and medicine.

Neutraceutical term as coined by De Felice, 1979, and is defined as "a food or parts of food, that provide medical or health benefits including the prevention and treatment of disease". It may range from isolated nutrients, dietary supplements and diets to genetically engineered designer foods, herbal products (e.g. Ginseng, garlic), processed products etc. Nutraceuticals are natural bioactive materials that provide demonstrated physiological benefits or reduce the risk of chronic diseases, above and beyond their basic nutritional function. Consumers' demand for quality of life has fueled the 'nutraceutical revolution' and seeking complementary or alternative beneficial products. The association of nutraceuticals with traditional medicine brings the long-standing consumer acceptance. Although the concept of nutraceuticals is gaining more popularity more recently, its roots can be traced to the ancient Indian system of medicine, '*Ayurveda*'. It is clearly stated that food, which besides providing nutrition helps to maintain the healthy state and prevents the occurrence of diseases should be consumed. The classical texts of *Ayurveda* are filled with scattered references of implication of food products in various disease entities.

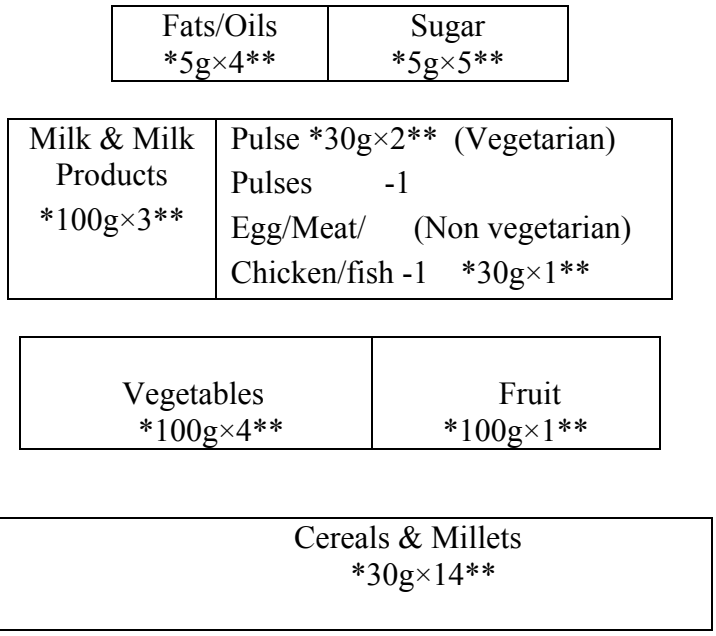
The various functional foods and their effect under study are-various Flavenoids, isoflavones and plant sterol in cardiovascular Disease; interaction between stress, food and mood; Ginkgo biloba and Alzheimer's disease; caffeine and mental performance & mood; enhancing performance sports food & drinks, green tea , polyphenols and its pharmacological functions; phytoesrtrogens and cognitive function etc.These functional foods are expected to play an important role in the modern nutrition, still the standards of food safety assessment, the concept of benefit vs. risk of long term intake needs to be validated and monitoring of their interaction with other food compounds and biological processes is required.

To promote healthy diet, governmental and other official bodies of countries have issued guidelines. National Institute of Nutrition has given the dietary guidelines for Indians for a balanced diet and good health throughout life

Composition of balanced diet

Balanced diet is a diet providing nutrients in the requisite proportions. It has been recommended that a balanced diet provide approximately 60-70% of total calories from carbohydrate source, 10-12%from protein source and 20-25% from fat. In addition, non nutritional nutrients as dietary fiber, antioxidants (such as –ß carotene, Vitamin C, E), and phytochemicals (e.g. Polyphenols, flavones etc.) needs to be provided by the balanced diet.

Balanced Diet for Sedentary Adult Man



* Portion size, **Number of Portions
Elderly man: Reduce 3 servings of cereals & millets, add extra serving of fruit.

Fig. 14: Balanced Diet for Sedentary Adult Man

Balanced Diet for Sedentary Adult Woman

Fats/Oils *5g×4**	Sugar *5g×4**

Milk & Milk Products *100g×3**	Pulse *30 g×2** (Vegetarian) Pulses -1 Egg/Meat/ (Non vegetarian) Chicken/fish -1 *30g×1**

Vegetables *100g×3**	Fruit *100g×1**

Cereals & Millets *30g×10**

* Portion size, **Number of Portions

Extra portions:
Pregnant Women - Fat/Oil-2, Milk-2, Fruit -1, Green Leafy Vegetable-1/2.
Lactating Woman - Cereal-1, Pulse-1, Fat/Oil-2, Milk-2, Fruit -1, Green Leafy Vegetable-1/2.
Elderly Woman: Reduce 2 servings of cereals & millets; add an extra serving of fruit

Fig. 15: Balanced Diet for Sedentary Adult Woman

Recommended dietary allowances (RDA) for average Indian

To maintain proper body functions, the body requires different nutrients in varying proportions depending on different factors such as age, sex, activity, body weight and height, physiological conditions (like adolescence, pregnancy or lactation etc).

Recommended Dietary Allowances (RDA) or Intakes (RDI) is defined as "the intake of nutrient derived from diet which keeps nearly all people in good health". While preparing RDA the individual variation and the diet-to-diet variability like bioavailability of nutrients, margin of safety are taken into account. These are optimal requirements for maintaining health and not average or minimum.

The Indian Council of Medical Research (ICMR) expert group has given the nutrient needs and RDA (recommended dietary allowances) for different nutrients for different age groups, for different activities based on the safe allowances as given by Food and Agriculture Organization (FAO) and World Health organization (WHO). These guidelines have been based on the following assumptions:

Reference man and woman

Reference Man is defined as "an adult man between 20-39 years of age, weighing 60kg and height of 163cms. He is free from disease and is physically fit for active work. On each working day, he is employed for eight hours in occupation that usually involves moderate activity. While not at work, he spends eight hours in bed, four to six hours in sitting and moving about and two hours in walking, active recreation or household duties."

Reference Woman is defined as "an adult woman between 20-39 years of age, weighing 50kg and height of 151cms. She may be engaged for eight hours in general household work, in light industry or in any other moderately active work. Apart from eight hours in bed, she spends four to six hours in sitting and moving around (light activity) and two hours in walking, active recreation or household duties."

For infants and children national Centre for Health Statistics (NCHS – USA) standards was used.

Energy Allowances

It is based on the equation given by FAO using BMR values derived from body weight. It is reduced by 5 % due to lower BMR for Indians.

Protein Requirement

Based on Indian mixed vegetable diets & considering NPU of 65, the requirement is recommended.

Fat requirement

The minimum EFA requirements and the invisible fat content of a cereal-based diet were also considered.

Minerals

Iron: Based on the levels of absorption in different cereal based diets (rice -5%; mixed cereal-3%; wheat and millet -2%) and on the basal loss, menstrual loss (in women) and growth requirement (in children), the requirements were estimated.

Calcium and Phosphorus: Due to the interrelation between calcium and phosphorus, the desirable ratio Ca: P of 1:5in infants and 1:1 in adults is considered.

Vitamins

Vitamin A: 1μg β carotene =0.25μg retinal. For conversion the following conversion factors are used:

a) Retinol content (μg) = μg Retinol + μg beta-carotene *0.25, if retinol and beta- carotene are expressed in μg.
b) Retinol content (μg) = vitamin A IU * 0.3 + beta-carotene IU * 0.15, if Vitamin A and beta –carotene are given in International Units.

Vitamin B Group: These are related to the energy intake; the recommendation is given per 1000kcal.In case of niacin, contribution of tryptophan is taken into account assuming 60mg dietary tryptophan yields 1mg niacin in the body.

Table 1: Recommended Dietary Daily Allowances for Indians (Macronutrients and Minerals)

Group	Particulars	Body wt(kg)	Energy(kcal)	Prt(g)	Fat(g)	Calcium(mg	Iron(mg)
Man	Sedentary		2425				
	Moderate	60	2875	60	20	400	28
	Heavy		3800				
Woman	Sedentary		1875				
	Moderate	50	2225	50	20	400	30
	Heavy		2925				
	Pregnant		300*	50*	30	1000	38
	Lactation						
	0-6months		550*	25*	45	1000	30
	6-12months		400*	18*	45	1000	30
Infants	0-6months	5.4	108/kg	2.05/kg		500	
	6-12months	8.6	98/kg	1.65/kg		500	
Children	1-3years	12.2	1240	22			12
	4-6years	19	1690	30	25	400	18
	7-9years	26.9	1950	41			26
Boys	10-12years	35.4	2190	54	22	600	34
Girls	10-12years	31.5	1970	57	22	600	19
Boys	13-15years	47.8	2450	70	22	600	41
Girls	13-15years	46.7	2060	65	22	600	28
Boys	16-19years	57.1	2640	78	22	500	50
Girls	16-19years	49.9	2060	63	22	500	30

- * -indicates addition to normal allowances

Vitamin D: No dietary recommendation given as exposure to sunlight provides adequate Vitamin D.

The daily recommended dietary allowances for macronutrients, minerals and vitamins for adult man and woman engaged in different activities and infants and children are tabulated in Table1 & 2.

Table 2: Recommended Dietary Daily Allowances for Indians (Vitamins)

Group	Particulars	Vit.A(µg) Retinol/ ßcarotene	Thiamine mg	Riboflavin mg	Nicotinic acid mg	Pyridoxine mg	Vit.C mg	Folic Acid µg	Vit.B12 µg
Man	Sedentary		1.2	1.4	16				
	Moderate	600/2400	1.4	1.6	18	2.0	40	100	1
	Heavy		1.6	1.9	21				
Woman	Sedentary		0.9	1.1	12				
	Moderate	600/2400	1.1	1.3	14	2.0	40	100	1
	Heavy		1.2	1.5	16				
	Pregnant	600/2400	0.2*	0.2*	2*	2.5	40	100	1
	Lactation								
	0-6months		0.3*	0.3*	4	2.5	80	150	1.5
	6-12months	950/3800	0.2*	0.2*	3	2.5	80	150	1.5
Infants	0-6months		55#	65#	710#	0.1	25	25	0.2
	6-12months	350/1200	50#	60#	650#	0.4	25	25	0.2
Children	1-3years	400/1600	0.6	0.7	8	0.9		30	
	4-6years	400/1600	0.9	1.0	11	0.9	40	40	0.2-1.0
	7-9years	600/2400	1.0	1.2	13	1.6		60	
Boys	10-12years	600/2400	1.1	1.3	15	1.6	40	70	0.2-1.0
Girls	10-12years	600/2400	1.0	1.2	13	1.6	40	70	0.2-1.0
Boys	13-15years	600/2400	1.2	1.5	16	2.0	40	100	0.2-1.0
Girls	13-15years	600/2400	1.0	1.2	14	2.0	40	100	0.2-1.0
Boys	16-19years	600/2400	1.3	1.6	17	2.0	40	100	0.2-1.0
Girls	16-19years	600/2400	1.0	1.2	14	2.0	40	100	0.2-1.0

- * - indicates addition to normal
- # - indicates the amount in µg/kg

Locally available foods: Inexpensive quality foods and foodstuffs rich in more than one nutrient

Man derives nutrients through the food he daily eats. Type and quantity of various foods depend on sociocultural & economic considerations. Each food in our diets, contain a wider range of nutrient, serves as the major source of one or two nutrients.

Cereals: Millets including ragi are rich in minerals & fiber especially in rice-based diets. Inclusion of some millet in a diet will help in making up deficiency of some of these minerals in the diet & in providing bulk (fibre) to diet.

Pulses: Protien of pulses are of low quality since they are deficient in methionine, but are rich in lysine. These supplement proteins of cereals. The most effective combination to achieve maximum supplementary effect is 4 parts of cereal protein + 1 part of pulse protein. In terms with the grains it will be 8 parts of cereal and 1part of pulses.

Vegetables: Green leafy vegetables (GLV) are rich source of calcium, iron, ß-carotene and vitamin C, riboflavin & folic acid. These are inexpensive and are advisable to include at least 50g of GLV's in the diet. Some of the important root vegetable like tapioca, potato, sweet potato, carrot, yam, and colocasia are important source of energy, carotene and calcium. Other vegetables add variety to the diet; provide vitamin C, some minerals and dietary fibre.

Milk and milk products: Milk is an important source of good quality protein; in addition it provides other nutrients especially calcium and riboflavin.

Eggs: Eggs proteins are considered as standard for evaluating the quality of other proteins. It has the highest nutritive quality as compared with any other dietary protein. They are rich source of all nutrients except ascorbic acid.

Flesh foods: They are rich in good quality protein, vitamin A. (liver) and vitamins B12.

Emphasis on nutritional adequacy

Thus diets could be improved by:

- Replacing single cereal by cereal pulse combination and mixed cereal for improving protein quality.
- For improving vitamin & mineral content at least 50g of green leafy vegetable is included.
- Diets including seasonal inexpensive yellow fruits help and improve vitamin A & C content of be diet.
- Addition of 150ml of milk to diet can improve protein and calcium content of the diet.
- Addition of at least 10g oil/fat will increase energy and EFA intake.

Suggested readings

1. Biochemical and Physiological aspects of human nutrition by Martha H Stipanuk, W B Saunders Company, Philadelphia, 2000.
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4. Essentials of nutrition & Diet Therapy by Sue Rodwell Williams, Eleanor D Schlenker, 8th edition, Mosby, inc Missouri, 2003.
5. Nutritive value of Indian Foods by C Gopalan, B V Ramasastri and S C Balasubramanian, revised & updated by B S Narasinga Rao, Y G Deosthale & K C Pant, National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, 2000.
6. Diet & heart disease by Ghafoorunissa & K Krishnaswamy, National Institute of Nutrition, Hyderabad, 1994
7. Dietary Guidelines for Indians-A Manual, National Institute of Nutrition, ICMR, Hyderabad, India,1998