HORTICULTURE

POST HARVEST TECHNOLOGY

Horticulture and Human Nutrition

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(15-10-2007)

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Keywords
Food guide pyramid, carbohydrates, protein, fat, vitamin, mineral, antioxidant, phytochemical, carotenoid, phenolics, body mass index

Introduction

Nutrition is most essential for normal body functions. We obtain this nutrition through chemicals found in food. Just like your body, food is a mixture of chemicals, some of which are essential for normal body functions. These essential chemicals are called **nutrients**. A nutrient is defined as a chemical whose absence from diet for a long enough time results in a specific change in health. We need nutrients for normal body growth and development, for maintaining cells and tissues, for fuel to do physical and metabolic processes. Foods provide six major classes of nutrients *viz*., carbohydrates, lipids, proteins, minerals, vitamins and water. The first five are called essential nutrients. Carbohydrates, protein and fats are called macronutrients because our bodies need large quantities of them. Our body needs comparatively small amounts of vitamins and minerals, so they are called micronutrients. Apart from nutrients, there are many other chemical substances, but they do not fit the classical definition of a nutrient. These include dietary fiber, enzymes and phytochemicals. The latest development in the field of nutrition is research on phytochemicals (plant chemicals), popularly called as antioxidants. They are abundantly found in fruits and vegetables and play an important role in reducing the risk of many chronic diseases including cardiovascular, cancer, and diabetes, macular and neurological degeneration.

The science of nutrition helps us to improve our food choices by identifying the amounts of nutrients we need, the best food sources of those nutrients we need, and other components in foods that may be helpful or harmful. Learning about nutrition will help us make better food choices, improve our health, reduce the risk of many chronic diseases and increase our longevity.

Functions of Foods

Do you "eat to live" or "live to eat". For most of us the first is certainly true, you must eat to live. But there may be times that it is enjoyment that is more important than nourishment. Factors such as age, sex, genetic makeup, occupation, lifestyle, family, and cultural background affect our daily food choices. We use food to express friendship, bond, relationship, creativity, and demonstrate feelings through gifts. Preference for food begins early and is mainly determined by age. Young children prefer sweet or familiar foods; babies and toddlers are generally willing to try new things. Teenagers are strongly influenced by preferences and habits of their peers. Their food choices are also influenced by senses and taste. This is the main reason why youngsters like to eat more of fast and junk food. Food habits and preferences are affected by number of factors. Lets us see what these factors are and examine them closely with functions of food.

(i)Food satisfies hunger: Hunger is a symptom indicating that the body's need for energy is not being met. Hunger is characterized by physical weakness, intermittent sensation of tension in the abdominal region (hunger pangs) and a driving urge to find food. When the person is under starvation, the body itself is used as source of energy and stored carbohydrate, fat reserves and proteins are all used for fulfilling the energy demand.

(ii)Food satisfies social needs: Social factors exert a powerful influence on food choice. Eating is also a social event that brings together different people for a variety of reasons (e.g. religious or cultural celebrations, business meetings and family dinners). Foods may also help one to achieve status, especially in these days, where eating out habits have more common, inviting your friends, relatives and boss to dine for a party are all instruments to develop social rapport.

Serving foods at social events – banquets, dinners, award functions, parties and meetings have all become important status symbols in modern times.

(iii)Cultural and religious needs: Like social needs cultural and religious factors also influence food choices. In many cultures, food has symbolic meaning related to family traditions, social status, and health. In certain cultures, use of spices and herb teas for purposes ranging from allaying anxiety to preventing cancer and heart diseases are very popular. Foods also form an important part of religious rites, symbols and customs as well as daily activities that are intended to promote an orderly relationship with supernatural forces. So foods may fulfill cultural and religious needs. Christianity, Hinduism, Islam and Buddhism all have distinct dietary laws, which give rise to variations to dietary practices. Islam faith prohibits consumption of pork, flesh of clawed animals, alcohol, and other intoxicating drugs. Intoxicating drugs are also prohibited in Buddhism. Most Hindus are vegetarians and donot eat eggs and meat. Similarly, Jain religion also forbids eating meat or animals.

(iv)Food builds body Tissues and regulates body processes: Nutrients are required for the general growth of the body. Proteins are required for building tissues. Calcium and phosphorus are involved in the development of skeleton and teeth. Fat and lipids are required for body building processes. These structural materials are especially needed during the active growth period. All the six nutrients help to regulate body processes. Each performs certain functions essential to normal body metabolism such as movement of fluids, control of acid and base balance, activation of enzymes and maintenance of body temperature.

(v) Foods are protective in function: Fruits and vegetables are called as functional foods because apart from nutrients, which are required to fulfill body's physiological needs, they also contain antioxidants, which protect the body against diseases such as cancer and cardiovascular diseases. Common antioxidants found in fruits and vegetables are ascorbic acid, β-carotene, phenolics and flavonoids.

(vi)Food supplies energy: One of the main reasons we eat foods and nutrients it contains, is for energy. Every cellular reaction, every muscle movement every nerve impulse requires energy. Three of the nutrient classes, carbohydrate, fat and proteins are sources of energy. These nutrients can be broken down completely (metabolized) to yield energy in a form that cells can use. The commonly used standard for measurement of energy value of substances is calorie. The unit used in the nutritional work is kilocalorie (K Cal) and is the amount of heat required to raise the temperature of 1 kg of water to 1^{o}C. Technically speaking the energy in foods is best measured in kilocalories; however, the term calorie has become more familiar.

Energy in Foods

Energy is available from foods because foods contain carbohydrates, fats and proteins. These nutrients can be broken down completely (metabolized) to yield energy in a form that cells can use. When completely metabolized in the body, carbohydrate and protein yield 4 kcal of energy; fats yield 9 kcal/g **(Fig 1).** Because of the large amount of carbohydrates normally eaten, it is usually the chief source of energy in the body. Fat is typically the second source followed by protein. Current health recommendations suggest limiting the fat intake to 30% of the total energy. In other words, during the day we should strive to eat less than 30% of those calories from fat. For example, if we need to eat 2000 kcal each day to maintain your current weight, 30% of calories

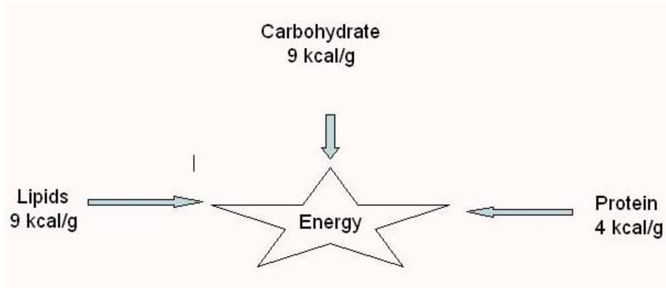


Fig. 1. Energy in Food

should come from fat. We should know how to calculate calories from foods if we want to monitor the fat content or the percentage of calories from each nutrient.

How to calculate the energy available from foods?: To calculate the energy available from food, multiply the number of grams of fat, carbohydrate and/or protein by 9, 4 and 4 respectively, then add the results. For example, if we assume that a food contains 39 g of carbohydrate, 10 g of protein, and 16 g of fat, we can determine the available energy from each component as:

39 g carbohydrate x 4 kcal/g = 156

10 g protein x 4 kcal/g = 40

16 g fat x 9 kcal/g = 144

Total = 340 kcal.

Energy needs vary considerably with life cycle stages. **Table 1** summarizes the individual energy needs of men and women. Energy needs as total kcal / day is greater, during adolescence than at any other time of life, with the exception of pregnancy and lactation. The energy requirement is increased by 300 k cal/day for pregnant and lactating mother. Active teenagers involved in regular exercise or sports will need excess energy. Conversely, teen with no regular exercise or fitness will not need this much energy for weight maintenance. Energy needs also decline with age reflecting loss of lean body mass and reduced physical activity.

Table 1: Energy requirements of individual groups

Group	**Age(yr)**	**kcal/day**
Male	11-14 15-18 >50	2500 3000 2300
Female Pregnant and lactating mother	11-14 15-18 >50	2200 2200 1900 2500

Older man expends about 20% less energy than young man. On the other hand there are minimal changes in energy expenditure of older woman in comparison to young woman. One proposed explanation is that men tend to reduce their physical activity when they retire, but women continue doing the bulk of the homework throughout the lives. Along with needs for energy, adolescent also need high protein, vitamin and minerals as compared to most other life cycle stages in order to support growth and maturation. Girls need more iron than boys to compensate for blood loss after onset of menstruation. Three nutrient of particular concern during adolescent age of growth and development are vitamin A, iron and calcium.

Nutrients, Balanced Diet: Food Guide Pyramids

Healthful food choices require a balance of food groups, energy sources (carbohydrates, protein, fats), and other nutrients. A balanced diet refers to intake of appropriate types and adequate amounts of foods and drinks to supply nutrition and energy for the maintenance of body cells, tissues, organs, to support normal growth and development. To achieve a balanced diet, you must consume a variety of foods from each of the food groups such as carbohydrates, protein, and fat. It is also important to note that about 50 to 60 % of our calories should come from carbohydrates, 12 to 20 % from protein, and 20 to 25% from fats. Apart from this balanced diet, should also contain the essential fatty acids and amino acids. The Food Pyramid is a visual representation of the balanced health guidelines and shows us how many servings to eat from each group every day for healthful diets. The Pyramid shows four principal food groups (**Fig 2**).

Fig. 2. Food Guide Pyramid

The bottom and largest section is the group of bread, cereal, rice, and pasta. Foods in this group are sources of complex carbohydrates and provide vitamins, mineral, and fiber. The next is the vegetable and fruit group. The Pyramid separates fruits and vegetables because of differences in nutrient composition. Vegetables provide vitamins such as vitamins A, C, folate, minerals (iron and magnesium) and carbohydrates including fiber. Fruits are rarely a good source of minerals other than potassium, but most are good sources of vitamins A and C. Taken together these three groups at the bottom of the pyramid illustrate that plant foods should make up the bulk of the diet. Next up are dairy foods, along with meat and meat alternatives (e.g., nuts, eggs, legumes).

They are important components of the diet, but we don't need as many servings to obtain the important nutrients from these groups. Dairy products provide vitamins (especially riboflavin and vitamins A and D), and minerals (calcium and phosphorous in particular). Meats and their substitutes are also good sources of protein, some of the B vitamins, iron, and zinc. The pinnacle of the Pyramid (smallest section) contains fats and sweets. These are the dietary "extras"- oil for cooking, sugar in tea or coffee, soft drinks and the like. All in all, Pyramid is easy-to-use guidelines that can help us select a variety of foods. The food Guide Pyramid is best way to select a balanced diet and achieve good health.

Dietary Standards: Recommended Dietary Allowance

Food guide pyramid deal with whole foods and food group, which tend to be more understandable to the average consumer than are individual nutrient values. Sometimes, we need more specific information about our nutritional needs or in other words how much nutrient we require daily. This is the purpose of dietary standards-to define healthful diets in terms of specific amounts of nutrients. Dietary standards are sets of recommended intake values of nutrients. It is a way to tell us how much of each nutrient we should have in our diets. These set of standard are called Recommended Dietary Allowances or RDAs. The RDAs for various nutrients are presented in **Table 2**.

Table 2 RDA values for vitamins and minerals

Nutrients	RDA
Vit A	1000 RE
Vit D	400 IU
Vit E	30 IU
Vit C	60 mg
Folate	400 µg
Thiamine	1.5 mg
Riboflavin	1.7 mg
Niacin	20 mg
Vitamin B 12	6 µg
Biotin	0.3 mg
Pantothenic acid	10 mg
Calcium	1000 mg
Phosphorus	1000 mg
Iodine	150 µg
Iron	18 mg
Mg	400 mg
Copper	2 mg
Zinc	15 mg
Chloride	3400 mg
Manganese	2 mg

Source: FDA from www.fda.gov

RE= Retinol equivalents; IU= International units; µg = microgram; mg=milligram

Evaluation of Nutritional Status: Nutritional health is quite simply obtaining all the nutrients in amounts needed to support body processes. The process of measuring nutritional health is usually termed as nutrition assessment. We can measure nutritional health in a number of ways. Taken together, such measurements can give us much insight into our current and long-term well being. Nutrition assessment serves a variety of purposes. It may help evaluate nutrition-related risks that may affect one's present or future health. Nutritional assessment is also part of the nutritional care of hospitalized patients and of an entire population-to identifies health risks of individuals and populations.

Nutritional status represents the health of an individual as influenced by number of factors such as the quantity and quality of nutrients consumed and the body's ability to utilize these nutrients to meet its metabolic needs. We can view nutritional status as a continuum of conditions, with the extremes being under nutrition and overnutrition. Chronic under nutrition results in development of nutritional deficiency diseases, as well as conditions of energy and protein malnutrition such as marasmus and kwashiorkor and can lead to death. Overnutrition is the chronic consumption of more than is necessary for good health. Specifically, overnutrition is the regular consumption of excess calories, fats, saturated fats or cholesterol- all of which increase the risk for chronic diseases.

Just as there is not measure of physical fitness, there is not just one indicator of nutritional health. There are number of factors that have to be looked to assess health. Often these are termed as ABCD's of nutritional assessment: Anthropometric measurements, Biochemical tests, Clinical observations, Dietary intake (**Table 3**). Anthropometric measurements are physical measurements of the body, such as height and weight, head circumference, girth measurements, or skin fold measurements biochemical tests involve measurement of nutrients or metabolite in body fluids such as blood or urine. Clinical examination includes observation of hair, skin, lips, mouth, bones, muscles and joints. Dietary intake involves collection of diet history and food record.

Table: 3 ABCDs of Nutritional Assessment

Assessment method	Why is it done?
Anthropometric measures	Measures growth in children weight, height, skin fold measurements, monitors progress in fat loss.
Biochemical method	Measures blood and/or urine and/or feces for nutrients or metabolites that indicate infection or disease.
Clinical observations	Assess change in skin colour and health, hair texture.
Dietary intake	Evaluates diet for nutrient (i.e. fat, protein) or food (i.e. fruits and vegetables) intake.

Another useful index in nutritional assessment is Body mass index (BMI) which being used to assess the level of obesity in body. BMI is a measure of body fat based on height and weight and applies to both adult men and women **(Table 4).** BMI provides a reliable indicator of body fatness and is used to screen for weight categories that may lead to health problems. A BMI of 25-29.9 indicates overweight and greater than 30 indicates obesity.

Table 4: Calculation of body mass index

Kilograms and meters (or centimeters)	Formula: weight (kg) / [height (m)]^2 With the metric system, the formula for BMI is weight in kilograms divided by height in meters squared. Since height is commonly measured in centimeters, divide height in centimeters by 100 to obtain height in meters. Example: Weight = 68 kg, Height = 165 cm (1.65 m) Calculation: $68 \div (1.65)^2 = 24.98$

Carbohydrates

Carbohydrates are organic compounds that contain carbon (C), hydrogen (H) and oxygen (O) in the ratio of 1 carbon atom and 1 oxygen atom for every two H atom (CH_2O). The simple sugar glucose, for example, contains 6-carbon atom, 12 hydrogen atoms and 6 oxygen atoms giving a simple carbohydrates, the formula ($C_6H_{12}O_6$). More than two sugar molecules can be assembled together to form complex carbohydrates. Our foods contain two types of carbohydrates, simple carbohydrates (sugars) and complex carbohydrates (starch and dietary fiber).

Simple sugars: Monosaccharides and Disaccharides: Simple carbohydrates are naturally present as simple sugars in fruits, milk and other foods. The two main types of simple sugars are monosaccharide and disaccharides Monosaccharide consists of a single sugar molecule ("mono" meaning one and "saccharide" meaning sugar). The most common monosaccharides found in the human diet are glucose, galactose and fructose (Fig 3). Disaccharides consist of two sugar molecules, chemically joined ("di" meaning two). Monosaccharides and disaccharides give various degree of sweetness to foods. Glucose is the main source of energy to the cells. Glucose imparts a mildly sweet flavour to foods. It seldom exists as monosaccharide in food but is usually joined to each other sugar to form disaccharides, dietary fiber and starch. Another important monosaccharide is fructose. Fructose also called the fruit sugar occurs naturally in fruits and vegetables. It is commonly used to sweeten cola and sweet drinks. Food manufacturers add high fructose corn syrup as additives to sweeten many foods, including soft drinks, desserts, candies, jellies and jams.

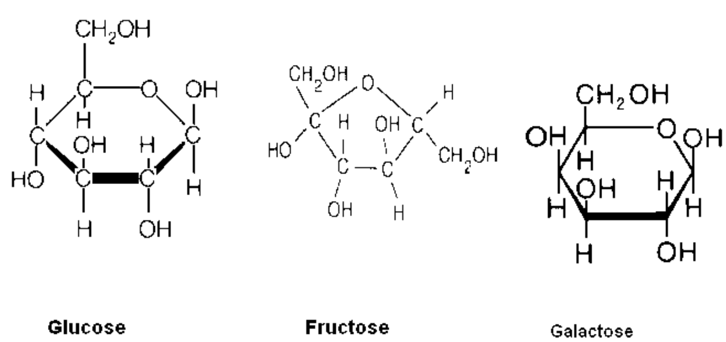
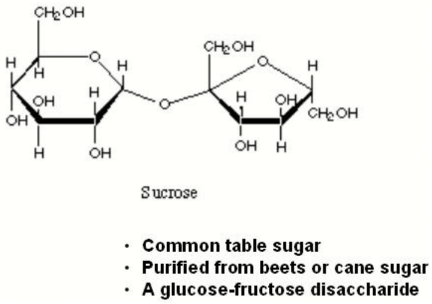
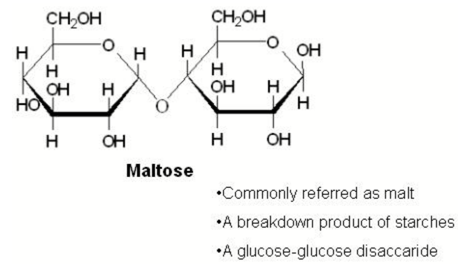


Fig. 3.Monosaccharides: Glucose, Fructose and Galactose

Disaccharides consist of two monosaccharide joined by a process of condensation. The important disaccharide sugars, important in human nutrition are sucrose (table sugar), lactose (sugar in milk) and maltose (a product of starch breakdown) (**Fig 4a,b,c**). Among disaccharides, only sucrose is found in fruits and vegetables.



(a)



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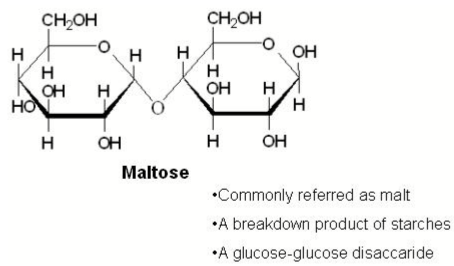

(c)

Fig. 4. Disaccharide

Complex carbohydrates: Complex carbohydrates are chains of more than two sugar molecules. They may be oligosaccharides or polysaccharides depending upon the chain length. Oligosaccharide is a short chain composed of 3 to 10 sugar molecules. Polysaccharides are long chain carbohydrates, composed of more than 10 sugar molecules **(Fig 5).** Fruits and vegetables are particularly rich in polysaccharides. The two common polysaccharides are starch and dietary fiber. Dietary fiber provides structure to plant cell wall and is found inside plant cells. They include cellulose, hemicellulose, pectin, gums and mucilage. Dietary fiber is often called non-starch polysaccharide. Food manufacturers add certain fibers to thicken foods and stabilize them. Pectin is usually added to jams, jellies, sauces, candies and drinks. The main difference between starch and dietary fiber is that starch is digestible in gastrointestinal tract but dietary fiber is not digestible. Foods rich in starch include grains (wheat, rice, corn, oats and barley), tubers (Potato, yam and cassava), and legumes (peas and beans).

Oligosaccharide

Polysaccharide

Fig. 5. Oligosaccharide and Polysaccharide

Carbohydrate, Digestion and Absorption: Glucose is a key building block of carbohydrates. When we drink chocolate milk or eat our daily meals, our body converts food carbohydrate into glucose. Carbohydrate digestion begins in the mouth where the starch-digesting enzyme salivary amylase hydrolyzes starch and mixes salivary amylase with food. When carbohydrates enter the stomach, the hydrochloric acid of stomach juices halts the action of salivary amylase. After leaving the stomach, the semi-liquid food passes into the small intestine where two juices viz. pancreatic juice and bile act on it. Bile juice helps in emulsification of fats so that they can be digested by pancreatic lipase. Hydrochloric acid also converts inactive form of protein splitting enzyme pepsinogen to the active enzyme pepsin. This stops carbohydrate digestion, which restarts in the small intestine. Most digestion of carbohydrate takes place in small intestine. As stomach contents enter the small intestine, the pancreas secretes pancreatic amylase through the pancreatic duct and into the small intestine. Pancreatic amylase continues the digestion of starch, breaking it into disaccharide maltose. Due to lack of certain enzymes in small intestine or the presence of indigestible structures like dietary fiber or resistant starch, some carbohydrates move to the large intestine intact. In the large intestine, bacteria breakdown undigested carbohydrates, producing gas and a few short chain fatty acids. Monosaccharide and fatty acids are absorbed into the mucosal lining of small intestine by diffusion and active transport. Through process of digestion our diet of carbohydrates (grains, fruits, vegetables and milk) becomes glucose, which supplies energy for the body.

Excess of glucose is stored in liver as glycogen and muscle tissue and hormones produced by the pancreas, closely regulate blood glucose levels.

Carbohydrates- Sources and RDA: Horticulture crops principally, fruits and vegetables are good source of simple and complex carbohydrates. Table 5 summarizes some important sources of simple and complex carbohydrates from fruits and vegetables.

Table 5: Fruits and vegetables rich in dietary fiber

Soluble fiber	**Insoluble fiber**
Apples, cranneberries, grapefruit, mango, oranges, apples, Bananas, Berries, cherries, Pears	Apples, bananas, cherries, pear
Asparagus, Brussels sprouts, carrots,	Broccoli, red cabbage, spinanch, sprouts
Peanuts, pecanuts, walnuts,	Almonds, sunflower seeds
Oat bran, oatmeal, Psyllium	Brown rice, whole-wheat breads

A diet rich in complex carbohydrates promotes a healthy body weight and lowers the risk of obesity. This is because foods rich in complex carbohydrates are usually low in fat and energy. They are also more fillings, offer a greater volume of food for fewer calories and take longer to eat. Once eaten, foods high in dietary fiber take longer to leave the stomach and they attract water, giving feeling of fullness. High intake of complex also lowers the incidence of type 2 diabetes, cancer. This is because fruits and vegetables apart from dietary fiber also contain antioxidants that may protect against cell damage that triggers cancer. Dietary fiber also lowers blood cholesterol levels. Dietary fiber also prevents constipation, and reduces risk of colon cancer. A minimum of 25-30 g of dietary fiber is required to stimulate normal gastric mobility. The fiber content of some fruits and vegetables is presented in **Table 6**. The daily value for carbohydrates is 300 grams in a 2000 k cal diet of a normal adult. This represents 60% of the total calorie requirement.

Table 6: Fiber Content in Some Fruits and Vegetables

Fruits & Vegetables	Serving size (g)	Total fiber (g)
Fruits:		
Apple	138	2.76
Banana	114	1.94
Cantaloupe	133	0.93
Grapes	100	1.0
Orange	131	2.49
Pineapple	0.88	0.13
Strawberry	149	2.68
Vegetables:		
Green beans	67	1.27
Broccoli	78	2.57
Cabbage	70	2.54
Carrots	72	1.19
Corn	83	1.74
Potato	156	5.05
Turnip	82	2.05
Peas	80	2.80

Lipids and Fats

Fats are the best-known members of a chemical group called the lipids. The term **lipid applies** to a broad range of organic molecules that dissolve easily in organic solvent such as alcohol, ether, or acetone, but are much less soluble in water. Lipids generally are **hydrophobic** (averse to water, literally "water fearing"). The main classes of lipids found in foods and in body are triglycerides, phospholipids, and sterols. According to their chemical structures, lipids are classified into three groups: 1) simple lipids or triglycerides (fats and oils). 2) Compound lipids (phospholipids and lipoproteins) and 3) derived lipids (fatty acids and sterols). Triglycerides are the largest category of the lipids. In foods we call triglycerides as "fats and oils" with fats being solid at room temperature and oils being liquid. Overall the terms are used interchangeably. In this section, when we use the term fat, we are referring to triglyceride. About 2% of dietary lipids are phospholipids and play a crucial role as major constituents in cell membranes, and in blood and body fluids where they keep fats suspended in these watery fluids. Only a small percentage of our dietary lipids are sterols, yet the most infamous one known to cause health problems.

A fat molecule may be composed of three fatty acids and glycerol. Fatty acids determine the characteristics of a fat, such as whether it is solid or liquid at room temperature. Fatty acids basically are carbon chains of various lengths with an organic acid, carboxyl group (-COOH) at one end and methyl group (-CH_3) at other end (**Fig 6**). If all the carbon atoms in the chain are connected by single bonds and the remaining ones are filled with hydrogen, the fatty acids is called a saturated fatty acid. However, if adjoining carbons are connected by a double bonds (c=c), the chain is not saturated and this is an unsaturated fatty acids (**Fig 7**).

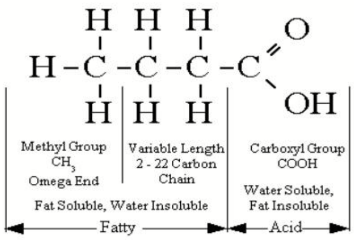

Fig. 6 Butyric acid

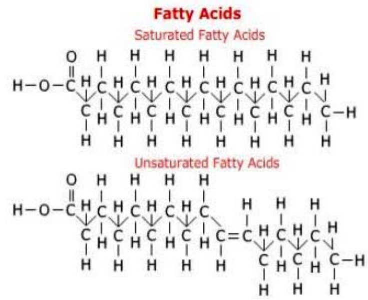

Fig. 7 Saturated and unsaturated fatty acids

Foods contain both mixtures of fatty acids, unsaturated and saturated fatty acids. A fatty acid with one double bond is called monounsaturated fatty acids (MUFA) and that with two or more double bonds is called a polyunsaturated fatty acid (PUFA). When all the fatty acids in a fat are identical, the molecule is called a simple triglyceride (TRG). A fat with different fatty acids is called a mixed TRG. TRG that are solid at room temperature are called fats and those that are liquid are called oils. Fats are usually high in saturated fatty acids and have high melting point whereas oils have more PUFA and have lower melting point.

The major fatty acid of soyabean oil is an 18-carbon fatty acid with two double bonds called linoleic acid whereas 18- carbon linolenic acid is found in flaxseed oil. Both the oils are thin liquid at room temperature. The major fatty acid of olive oil is 18- carbon fatty acid oleic acid.

Phospholipids are made of glycerol, two fatty acids and a phosphate group with a nitrogen-containing component. Phospholipids found in every living cell are formed primarily in the liver from the alcohol, glycerol, fatty acids, phosphoric acid and a nitrogenous base. Among sterols, cholesterol (CHOL) is the best known and has attracted attention because of the association of elevated blood CHOL levels with other sclerosis and coronary heart disease. Among lipoproteins LDL (low density lipoprotein) and HDL (high density lipoprotein) are important. LDL is also called bad CHOL, whereas HDL is good CHOL. Presence of LDL is one of the risk factor in coronary heart diseases

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Essential Fatty Acids: Our bodies cannot produce certain fatty acids such as linoleic acid and linolenic acid. They must come from food, so they are called essential fatty acids (EFA). It is essential for growth and maintenance of normal skin. Seed, nuts and vegetable oils (soyabean oil, flaxseed oil and canola oil) are rich sources of linoleic and linolenic acid.

Digestion, absorption and metabolism of fats: The digestion of fats begins in the small intestine. Bile (from liver) juice and pancreatic lipase are the two important secretions involved in splitting of fat. Bile neutralizes the acidity of the food mass and helps in emulsification of fat globules, which are hydrolyzed by pancreatic lipase to glycerol and fatty acids. The oxidation of glycerol and fatty acids in the body cells occurs in two ways. The glycerol portion is metabolized like a carbohydrate to form pyruvic acid, fatty acids changes to acetyl CoA and enters citric acid cycle and is oxidized to CO_2, H_2O and energy (ATP).

Functions of fats and other lipids

(i) Source of energy: Fats and oils are source of energy in the diet. One gram of fat contains 9 k calorie compared to only 4 k calorie in a gram of carbohydrate or protein. Under normal circumstances, dietary and stored fats supply about 68% of body's resting energy needs. They are the more concentrated form of energy in foods. In the body, fats are deposited under the skin where they function as nonconductors of heat, helping to insulate the body and prevent rapid loss of heat.

(ii) Energy Reserve, Insulation and Protection: The body stores excess dietary fat in body to tide over period of caloric deficit. The fat is stored inside fat cells called adipocytes. Hibernating animals have perfected this process; the fat stores they build in autumn can see them through a winter's fast. Fat tissue also serves an important function by cushioning and shielding delicate organs, especially the kidneys.

(iii) Carriers of fat-soluble compounds: Dietary fats dissolve and transport micronutrients such as fat-soluble vitamins and fat-soluble phytochemicals like carotenoids (**Fig 8)**. These phytochemicals also called as antioxidants, are one of important compounds that help in improving health and reducing the risk of chronic diseases such as cancer and cardiovascular disease.

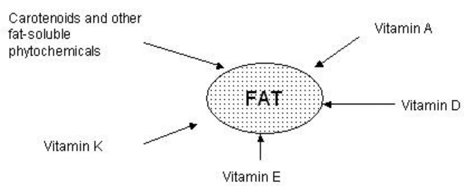

Fig. 8 Fat a micronutrient carrier

(iv)Sensory qualities: Fats have a rich, satisfying feeling in mouth. As a food component fat contribute greatly to the flavour, odor and texture of food.

Functions of phospholipids and sterols: Phospholipids are components of cell membranes and lipoproteins. They have a unique affinity for both water and fat. That is why they are used as effective emulsifiers in foods. Egg yolk phospholipids are used as emulsifying agent to emulsify and stabilize mayonnaise (oil and vinegar emulsion). The best-known sterol is cholesterol. It is an important structural component of cell membranes and is abundant in nerve and brain tissue. Cholesterol is also a precursor molecule of gluco-corticoids, mineral corticoids, androgen and estrogens. Diets high in fat and saturated fat tend to increase blood levels of LDL cholesterol and increase the risk of heart diseases, and obesity.

Recommended dietary allowance and sources of fats: The most abundant sources of fat in the diet are vegetable oils (corn oil, peanut oil, olive oil) and animal fats (beef fat and butter). Nuts also rank with pecan nuts containing the most fat and cashews the least. Cheese and egg yolk are also good sources of fat. Eggs, butter, lard and meat particularly organ meat such as kidney, liver and brain are high in cholesterol. Plant foods, on the other hand never contain cholesterol.

Proteins

The word protein was coined by Dutch chemist Gerardus Mulder in 1838 and comes from the Greek word protos, meaning of 'prime importance. Proteins are a major component of all plant and animal tissues; second only to water just as glucose is the basic building block of carbohydrates, amino acids are the basic building blocks of protein. Proteins are in fact a sequence of amino acids. Our body has 20 different amino acids, out of which 9 are called essential amino acids. They are called essential because our body cannot make them and must get them from diet. Our body can manufacture the remaining 11, called non-essential amino acids, when enough nitrogen, carbon, hydrogen and oxygen are available. **Table 7** lists some essential, non-essential and conditionally essential amino acids. A conditionally essential amino acid is normally made in the body (nonessential) but becomes essential under certain circumstances such as during critical illness.

Table 7: Essential and non-essential amino-acids

Essential	Non-essential	Conditionally essential
Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan and Valine.	Alanine, Arginine, Asparagine, Aspartic acid, Cysteine, Glutamic acid, Glutamine, Glycine, Proline, Serine, Tyrosine.	Arginine, cysteine, Glutamine

Functions of Proteins: In the body, proteins perform numerous vital functions:
(i)They act as enzymes: Enzymes are proteins that catalyze chemical reactions without being used up or destroyed in process during digestion. Enzymes help breakdown carbohydrates, proteins and fats into simpler molecules and energy released during the process is used as fuel.

(ii)Hormones: Many hormones are proteins, which play a key role in regulatory functions. Insulin e.g. is a protein hormone that plays a key role in regulating the amount of glucose in the blood. Thyroid stimulating protein (TSH) and leptin are two protein hormones. Leptin is produced by fat cells and plays an important role in regulating body weight.

(iii) Immune functions: Proteins are responsible for fighting infection and invasion by foreign substances. Antibodies are body proteins that attack and inactivate blood bacteria and viruses that cause infection. When diet does not contain enough proteins, body cannot make as many antibodies as it needs.

(iv)Maintain fluid balance: Proteins in blood keep maintaining appropriate fluid levels in vascular system. When the heart pumps blood, the fluid from blood is forced out in the interstitial fluid. But proteins like globulin and albumin are too large and thus are retained in the capillaries. They, thus, attract fluid and maintain balance.

(v) Acid-base balance: Proteins help to maintain stable pH levels in body fluids by serving as buffer; they can either donate or accept hydrogen ions to maintain stable pH levels. If proteins are not available, blood can become too acidic or too alkaline, resulting in either acidosis or alkalosis.

(vi)Transport functions: Proteins also act as carriers, transporting many important substances in the blood stream for delivery throughout the body. Lipoproteins, for example, package proteins with lipids so that lipid particles can be carried in the blood.

(vii) Source of Energy and Glucose: Although our body preferentially burns carbohydrate and fat for energy, if necessary it can use protein for energy or to make glucose. This is what happens in case of starvation. When the diet does not provide enough energy to sustain vital functions, the body sacrifices its own proteins (from enzymes, muscle and other tissues) to make energy and glucose. However, if the diet contains more protein than is needed for protein synthesis, excess is converted into glucose or stored as fat.

Digestion and Absorption of protein: Protein digestion begins in the stomach, where the enzyme pepsin breaks proteins into smaller peptides. Digestion continues in the small intestines, where proteases break polypeptides into smaller peptide units, which are then absorbed into cells where additional enzymes complete digestion to amino acids. Key enzymes are pepsin in the stomach, and trypsin and chymotrypsin from the pancreas.

Protein Quality, Source and RDA: Although both animal and plant foods contain protein, the quality of protein in these foods differs. Foods that supply all essential amino acids in the proportions needed by the body are called complete or high quality proteins. Animal foods generally provide complete protein i.e. they provide all the essential amino acids in right proportions. Red meat, fish, eggs, milk and milk products (all animal foods) contain complete proteins. People usually associate proteins with animal foods like beef, chicken, fish or milk. However plant foods such as dried beans, peas, grains, nuts and vegetables also are good sources. Starchy vegetables (corn, potato) legumes (lentils, kidney beans), vegetables (broccoli, cauliflower, peas and Brussels's sprouts) and nuts (peanut and sunflower seeds) are the main sources of protein (**Table 8**).

Table 8: Plant sources of protein

Plant protein source	Gram of protein	Kilocalorie
Grain products		
Whole wheat bread(2 slices)	**6**	**138**
One cup cooked brown rice	**5**	**216**
Starchy vegetables		
1one medium baked potato	**4**	**228**
One cup cooked corn	**5**	**177**
One cup baked hubbard squash	**5**	**103**
Legumes		
1 cup lentil	**18**	**230**
I cup cooked kidney bean	**15**	**225**
Vegetables		
Cooked broccoli	**5**	**44**
Cauliflower	**2**	**29**
Brussel sprouts	**4**	**61**

Source: USDA Nutrient Database for Standard Reference

With the exception of soy proteins, the plant protein is incomplete, that is, it lacks one or more essential amino acids. Although the protein in one plant food may lack certain amino acids, the protein in another plant food may be a complimentary protein that completes the amino-acid pattern. For example, grain products such as pasta are low in essential amino-acids lysine, but high in essential amino-acids methionine and cysteine. On the other hand, legumes such as kidney beans are low in methionine and cysteine but high in lysine. So combining these foods can give us complete protein. Generally, when you combine grain with legumes, or legumes with nuts, we can get complete proteins. Protein complementation is important only for people who consume little to no animal proteins. For them, a wide variety of plant proteins are key to obtaining adequate amounts of all essential amino acids. Boosting our intake of plant proteins can provide benefits. High proteins are usually rich in vitamins, minerals and dietary fiber.

The protein in soybeans is a notable exception to the rule that most plant proteins are not complete. Soy provides complete high-quality protein compared to that in animal foods. In addition, soyabeans provide no fat or cholesterol, and are rich in iso-flavonids- the phytochemicals, that reduce risk of heart disease and cancer and improve bone health. It is easy to incorporate a variety of soya foods into your diet. Tofu, tempeh, ground soy milk-soy flour, textured soy protein are soy-based products that can be included in many meals and snacks. Infants, who are growing rapidly, have the highest protein needs relative to body weight. The recommended dietary allowance (RDA) for protein is 202 grams for infants and 50 grams for adults**.** Excessive dietary protein, than RDA may contribute to loss of bone, calcium, obesity heart disease and certain forms of cancer.

Malnourishment: Proteins play a vital role in many body processes and deficiency of protein can disturb the entire metabolism of the body. Protein deficiency occurs when energy and/or protein intake is inadequate or if the protein they eat is of poor quality or cannot be absorbed. Although protein deficiency is widespread in poverty-stricken communities and in some non-industrialized countries, most people in industrialized countries face the opposite problem – protein excess. Without adequate energy intake, the body burns dietary protein for energy rather than using it to make body proteins.

Protein-Energy Malnutrition: A deficiency of protein, energy or both in the diet is called protein-energy malnutrition. (PEM). PEM is most often a condition of infants and children. It is most common in Africa, South and Central America, East and South-East Asia and Middle East. In industrialized countries, PEM occurs most often in populations living in poverty. Two common forms of PEM prevalent are **Kwashiorkor** and **Marasmus**. Kwashiorkor is an acute form of PEM, whereas marasmus develops from chronic PEM. Typical symptoms of Kwashiorkor include edema or swelling of body tissue, usually in feet and legs. Lack of blood proteins reduces the force that keeps fluid in blood stream resulting in their leakage in tissues. The belly becomes bloated from both edema and accumulation of fat in the liver. Other symptoms include stunted weight and height, increased susceptibility to infection, dry and flaky skin, and sometimes skin sores, dry and brittle hair, and changes in skin colour. Kwashiorkor usually develops in children between the age of 18 and 24 months, about this time weaning occurs.

Marasmus is derived from the Greek word 'Marasmus' which means 'withering' or 'to waste away'. It develops more slowly than Kwashiorkor and results from chronic PEM. Growth is retarded and children are short and thin and even cannot cry. Their hairs are sparse and fall out easily. It usually occurs most in infants in 6-18 months of age, who are fed on inadequate protein diet. Since this is a time of rapid brain growth, marasmus can permanently hamper brain development and lead to learning disabilities.

Vitamins and Minerals
Vitamin and minerals cannot be synthesized by human body and must be provided by the diet, although only small amounts are required daily; therefore they are called micronutrients and required for specific functions in body **(Fig 9).** Scientists categorize vitamins based on their solubility. Vitamin A, D, E and K are lipid-like molecules that are soluble in fat. The B vitamins and vitamin C, on the other hand are soluble in water. This difference in solubility affects the way the body absorbs, transports and stores vitamins. Also water-soluble vitamins are more susceptible to destruction by heat or alkalinity, which can break the chemical bonds between atoms. Vitamin C and thiamine and riboflavin are particularly vulnerable to heat and alkalinity. Vitamins and minerals are found throughout the groups that make up the Food Guide Pyramid, but more precisely fruits and vegetables are known to be best sources of vitamins and minerals.

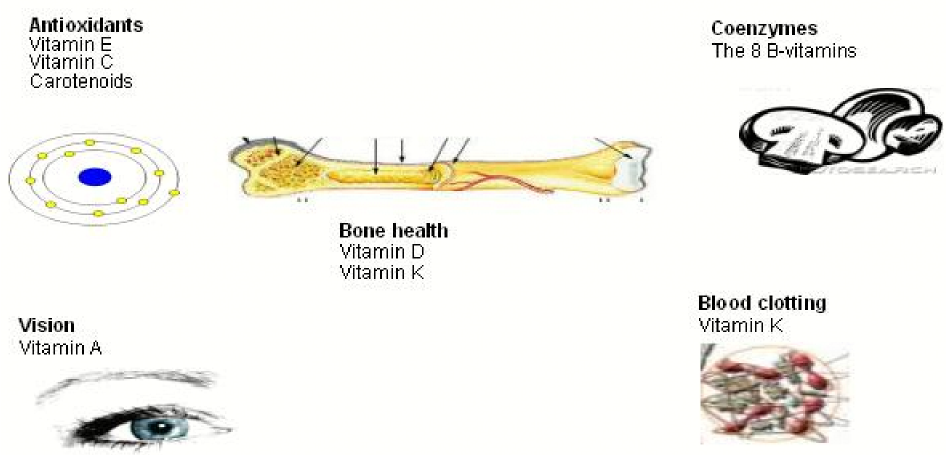

Fig. 9 Major roles of vitamins

Water soluble vitamins: Eight Bs and a C: Water-soluble vitamins consist of the eight B vitamin and a vitamin C. Earlier scientists thought that vitamin B was a single compound, but later they discovered that it was actually several vitamins. To differentiate the various B vitamins, scientists initially added numbers to the letter, for example, B-vitamin B_6 and B_{12}. Today, with exception of B_6 and B_{12}, vitamin B is referred by their names: thiamine (B_1), riboflavin (B_2), niacin (B_3), pantothenic acid, biotin and folate. The B vitamins act primarily as coenzymes, or as parts of co-enzymes (compounds that enable specific enzymes to function). The B vitamin part of a coenzyme helps catalyze the working of metabolic pathways in the cells. All B vitamins function in energy producing metabolic functions, and some also participate in other aspects of cellular metabolism. During the milling process, much of the B vitamin is removed along with the germ, bran, and husk. The addition of B vitamins thiamine, riboflavin and niacin helps restore the lost vitamins.

Vitamin B

(i)Thiamine (B_1) : Thiamine is popularly known for its deficiency disease beri-beri. Deficiency of thiamine leads to beri-beri, caused by deficiency of polished rice is common where polished rice is a major dietary item. Fortification of rice or white bread with thiamine corrects this disease. . Like the other B vitamins, thiamine is an important participant in many energy-yielding reactions. It is the vitamin portion of the coenzymes, Thiamin pyrophosphate (TPP). TPP also plays a role in nerve function and produces energy to fuel nerve tissue. Symptoms of berberi are nerve degeneration, loss of nerve transmission, muscle wasting, poor arm and leg coordination and deep pain in calf muscles.

Important to the food technologist is the sensitivity of thiamine to sulfur dioxide (SO_2), a common preservative. Sulphur-dioxide destroys the vitamin activity and should not be used to preserve foods that are major sources of thiamine. The RDA for thiamine is 1.0-1.5 mg, depending upon age and sex. Wheat germ, whole cereals, liver, egg yolk orange juice and carrots are good source of thiamine.

(ii)Riboflavin: Riboflavin is the yellow-green colour pigment of skim milk and whey. It functions in the oxidative processes of living cells and is essential for cellular growth and tissue maintenance. Riboflavin deficiency known as ariboflavinosis has characteristics that include some throat, inflammation of tongue, and mouth, disease of oil-producing glands of the skin and anemia. Riboflavin is resistant to acid, heat but sensitive to light and this is why paper cartons is a preferred packaging material for milk instead of bottles. RDA for adult is 1.2-1.7 mg and liver, milk and eggs are good sources.

(iii)Niacin: Niacin also referred to as nicotinamide and like other B vitamins, is as coenzyme component of many oxidation-reduction reactions. Niacin is unique among the B vitamins because our body can make it from an amino acid tryptophan. Deficiency of niacin in body leads to a disease pellagra, which is characterized as 3Ds: dementia, diarrhea and dermatitis. The RDA is 13-20 mg niacin and good sources are meat, fish legumes and whole grain cereals.

(iv)Vitamin B_6 : Vitamin B_6 is coenzymes to enzymes that support protein metabolism, blood cell synthesis, carbohydrate metabolism and neurotransmitter synthesis. One of the primary tasks of vitamin B_6 is to keep metabolize amino acids and other nitrogen-containing compounds. Over time, Vitamin B_6 deficiency impairs protein synthesis and cell metabolism. Inadequate vitamin $B_{6,}$ causes microcytic hypochromic anemia. In this type of anemia, red blood cells are smaller than normal and lack sufficient hemoglobin to carry oxygen. The RDA is 2 -2.2 mg and meats are generally good sources of vitamin B_6 along with certain fruits (e.g. banana and watermelon) and vegetables (e.g. potatoes and carrots).

(v)Pantothenic acid: The name pantothenic acid is derived from the Greek word pantothen meaning ‘from every side’. This B vitamin is widespread in the food supply, so it is well named. Pantothenic acid is a component of coenzyme A (CoA), which in turn is a component of acetyl CoA. Pantothenic acid deficiencies are virtually nonexistent in the general population. However, people in whom metabolism pantothenic acid is lacking suffer from irritability, restlessness, fatigue, nausea, muscle cramps and hypoglycemia. The RDA is 5 mg per day.

(vi)Vitamin B_{12} : Vitamin B_{12} is also called cobalamin, generic term that describes a group of cobalt-containing compounds. Vitamin B_{12} plays a key role in folate metabolism. That's why deficiency of vitamin B_{12} deficiency can lead to the deficiency of folate. General symptoms of Vitamin B_{12} deficiency include megaloblastic anemia, and a variety of neurological disorders. The major outcome of impaired vitamin B_{12} is pernicious anemia. This leads to the abnormal red blood cells and nerve degeneration. If not treated, it leads to death. Folate, vitamin B_{12} and vitamin B_6 all play key roles in the metabolism of aminoacids, homocysteine, which has been implicated in heart disease. Unlike the other B vitamins, Vitamin B_{12} is not normally present in plant foods and is found only in animal foods. Milk, beef and fish are richest sources of B_{12}. RDA for adults is 2.0 µg.

(vii)Folate: Spinach and other dark green leafy vegetables asparagus, broccoli, orange juice, wheat germ, sunflower seeds and legumes are good sources of folate in diet. Folate in body is converted into tetrahydrofolic acid (THFA), which is involved in DNA synthesis, amino acid metabolism, cell division and maturation of red blood cells and other cells.

Recent research suggests that folate has an important role in preventing heart disease. Folate works with vitamin B_{12} and vitamin B_6 to reduce elevated homocysteine, which is a risk factor for heart attacks. When folate is deficient in the diet, homocysteine level rises. This increases the risk of heart attacks. Also, poor folate during the early stages of pregnancy leads to an increased risk of a birth defect known as a neural tube defect (NTD). In this type of birth defect, the neural tube fails to increase the spinal cord during early fetal development. This causes a number of disorders such as spine bifida. Therefore pregnant women are advised to take 400 µg of folic acid each day from fortified foods or supplements, in addition to dietary folate.

(viii)Biotin: In food, biotin is found in both free and bound to protein. When proteins are digested, a biotin-lysine complex called biocytin is released. Biotin plays a major role in catalyzing reactions involved in citric acid cycle, synthesis of fatty acid and DNA. Most fruits and vegetables rank as poor sources. Good sources of biotin include cauliflower, liver, peanuts, cheese and egg yolk. White yolk contains a protein avidin, which binds to biotin and prevents its absorption. Hence we should avoid eating raw eggs because this can lead to deficiency of biotin and sometimes food poisoning as well.

Vitamin C: Vitamin C is the antis curvy vitamin and is also known as ascorbic acid. Vitamin C is an antioxidant – it acts as a reducing agent and participates in many reactions by donating electrons or hydrogen ions (**Fig 10**). Fresh fruits and vegetables are good sources of vitamin C. Citrus fruits, guava, tomatoes, broccoli, straw berry, kiwi fruit, cabbage, spinach, green peppers and other leafy greens include good sources of vitamin C. Scurvy is the well-known vitamin C deficiency disease although it is rare today. The body loses its ability to synthesize collagen, connective tissue starts breaking down and gums and joints begin to bleed. The RDA is 60 mg for adults. Vitamin C is easily destroyed by oxidation, especially at high temperatures, and is the vitamin most easily destroyed during food processing, storage, and cooking.

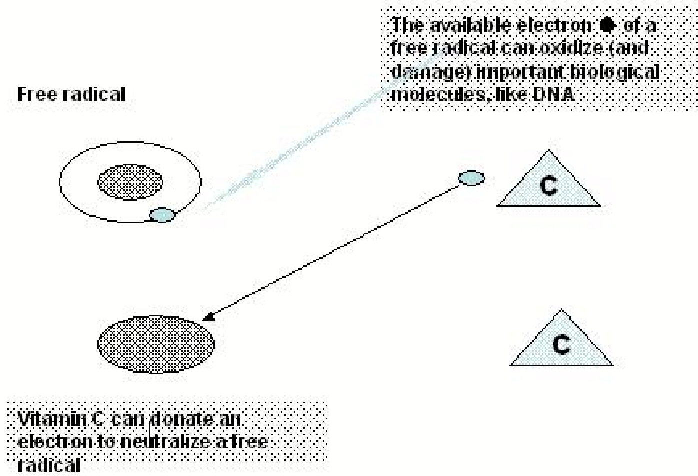

Fig. 10 Vitamin C as an antioxidant

Vitamin A: Vitamin A is best known for its role in vision, but it is crucial for proper growth, reproduction, immunity, and cell differentiation. It helps in maintaining healthy bones as well as skin and mucous membranes. Deficiency of **vitamin A** results in progressive vision loss from temporary night blindness, to reversible blindness, and finally permanent blindness. Retinol is the most active form of **vitamin A**, which is required for reproduction and bone health. Our body can easily convert retinol, the form that is required for reproduction and bone health, to retinal, the form of vitamin A essential for night and color vision. In return, retinal can also be converted into retinol. The inter-convertible nature of retinol and retinal allows them to support all activities of the vitamin A family. Plants do not contain vitamin A but contain its precursor, β-carotene.

This is the reason we should eat plenty of yellow coloured fruits and vegetables and green leafy vegetables to increase the intake of vitamin A. RDA for vitamin A is 1000 RE (retinol equivalents).

Vitamin E: Vitamin E is really a set of compounds called tocopherols and tocotrienols, but in the body, alpha-tocopherol is the only active vitamin E compound. Vitamin E functions as an antioxidant, protecting cell membranes in all parts of the body from damaging effects of oxidation. Vitamin E has been connected to reduction of risk for many degenerative diseases such as heart disease, cancer and Alzheimer’s disease. Its antioxidant activity is enhanced by presence of other antioxidants such as vitamin C and selenium. The RDA for vitamin E is 1.5 mg of alpha-tocopherol for men and women.

Vitamin D: Vitamin D is sometimes called the sunshine vitamin. Vitamin D is unique because given sufficient sunlight; your body can synthesize all it needs of this fat-soluble nutrient. When the ultraviolet rays of the sun strike the skin, they alter a precursor derived from cholesterol, converting it into vitamin D. Although fortified milk and other food supply vitamin D, our body can make plenty as long as it gets regular exposure to sunlight. The best-known functions of vitamin D, in the active form are to help regulate blood calcium levels. Intake recommendations for vitamin D are very small, only 5 μg per day for young adults. Needs from the diet, increase with age as the ability of the skin to synthesize vitamin D declines. Few foods are naturally good sources of vitamin D, and so most of the dietary intake comes from fortified milk and other fortified foods. Deficiency of vitamin D leads to rickets in children and in adult's lack of nutrient cause's osteomalacia and osteoporosis. In children, 400 IU of vitamin D is considered optimum, and this is basis of fortifying milk with vitamin D.

Vitamin K: In 1929, Danish researcher Henrik Dam discovered a nutrient, vitamin K that plays a crucial role in blood clotting. It helps in preventing excessive blood loss during the event of an injury or accident by promoting the formation of blood clots. Turnips, spinach, cauliflower, cabbage, green beans, green tomato, asparagus and strawberry are important sources of vitamin K.

Water: Water is the most essential nutrient; we can survive much longer without food than without water. The function of water in the body includes temperature regulation, metabolism, acid base regulation, lubrication and protection. Water is the major component of all body fluids. These fluids serve essential mechanical functions such as shock absorption, lubrication, cleansing and protection. For example, amniotic fluid provides a gentle cushion that protects the foetus, synorial fluid allows joints to move smoothly, tears lubricate and cleanse the eyes, and sativa moistens food and makes swallowing possible. The balance of body fluids and the amount of electrolytes dissolved in the body's water are controlled precisely. Potassium is the main intracellular cation and sodium the main extra-cellular cation. Generally, we should drink 8 to 10 glasses of water every day.

Minerals

Minerals are inorganic elemental atoms or ions and unlike carbohydrates, proteins, and fats, minerals are not changed during digestion or when the body uses them. They are also are not destroyed by heat, light, or alkalinity. Calcium remains calcium, iron remains iron and this is true for all the minerals. Minerals are categorized as major or trace minerals based on the amount needed in the diet and the amount of mineral in the body. The body requires more than 100 mg per day of each major mineral, while the dietary need for each trace mineral is less than 100 mg daily. Trace elements include iron, zinc, copper, manganese, molybdenum, selenium, fluoride, iodine and chromium. Minerals play many essential roles in the body. Despite the minuscule amounts requited in the body, trace elements are crucial to body functions including cofactors for coenzymes, components of hormones, and participants in oxidation-reduction reactions. Generally speaking, animal foods are more reliable sources of minerals than plants are because animal tissues contain minerals in the proportion that animal tissues need.

(i)Sodium: Sodium is the major cation in extra-cellular fluid and a critical electrolyte in the regulation of body fluids. It acts in concert with potassium, the major cation in intra-cellular fluid, and chloride, the major anion in extra-cellular fluid, to maintain proper body water distribution and blood pressure. Nerve transmission and muscle functions require sodium. It also helps control the body's acidity, and aids the absorption of some nutrients such as glucose. There is no RDA for sodium. The American Heart association recommends that individuals should avoid taking more than 2,400 mg of sodium per day.

(ii)Potassium: Just as sodium is the major extra cellular cation, potassium is the key cation in cells. Potassium helps in regulating blood pressure. If people with hypertension eat a diet rich in potassium-containing foods (like fruits and vegetables), their blood pressure often improves. Intra-cellular fluid contains 95% of the body's potassium, with the highest amount in skeletal muscle cells. The flow of sodium and potassium in and out of cells is an important component of muscle contractions and the transmission of nerve impulses. Fresh fruits and vegetables, especially potato, spinach, melons and bananas are major dietary sources of potassium. A healthy diet has an average 2000 to 4000 mg of potassium per day.

(iii)Chloride: Chloride is the major extra-cellular anion in the body in conjunction with sodium and helps to maintain the body's fluid balance.

(iv)Calcium: Calcium is the key mineral found in our body. Our bodies contain more calcium than any other mineral, about 1.5 to 2% of our total weight. Adequate calcium intake over one's life time is essential for healthy bones and teeth. Getting enough calcium in your diet, not only maintains healthy bones, but also prevents hypertension, decrease odds of getting colon or breast cancer and reduces risk of developing kidney stones. Green leafy vegetables such as spinach, have high levels of calcium. Other vegetables rich in calcium are broccoli, cauliflower, cabbage, brussels sprouts and turnip greens. For adults, 1,000 mg of calcium is recommended, and more is suggested for adolescent and older adults.

(v)Phosphorus: Phosphorus like calcium serves many roles in the biochemical reactions of cells and has a critical role in bone formation. Generally, foods rich in protein (milk, meat and eggs) are rich in phosphorus.

(vi) Magnesium: Magnesium is ubiquitous in foods, but the amount varies widely depending on the food source. Whole grains, almonds and vegetables such as spinach and potatoes are good sources of magnesium. Magnesium is the fourth most abundant cation in the body and about 50 to 60% of the body's magnesium is in bones.

(vii) Sulphur: Sulphur is different from the other minerals discussed in the chapter because it is not used alone as a nutrient. In the body, sulphur functions as component of organic compounds, such as vitamins biotin and thiamine and the amino acids methionine and cysteine. The cabbage and onion families have sulphur- based compounds that are transformed into odiferous compounds when tissues are broken.

(viii)Iron: Iron is well known for its role in body's use of energy; it is required for oxygen transport and is an essential component of hundreds of enzymes. Iron is an component of heme proteins hemoglobin, which helps in transportation of oxygen in the body. Iron absorption in meal depends on presence of organic acids such as ascorbic acid, citric, malic and tartaric acid. A varied diet (adequate in calories, rich in fruits and vegetables, and with small amounts of lean animal flesh) generally provides adequate iron. Vegetarians who consume no animal tissue can maximize iron availability from other sources by consuming vitamin C rich fruits and vegetables.

(ix)Zinc: Zinc is critical to the proper function of more than 80 enzymes and metallo-proteins (proteins that have a mineral as an essential part of their structures). Zinc is essential for a number of diverse biological functions, including cell growth, replication, fertility reproduction, immune function, sexual maturation and night vision. Zn deficient people may show signs of night blindness. Zinc is usually abundant in foods that are good sources of protein especially red meat and seafood. Fruits and vegetables are generally poor sources of dietary zinc.

(x)Iodine: Iodine is an essential component of thyroid hormones triidothyronine and thyroxine. Thyroid hormones control the regulation of body temperature, basal metabolic rate, reproduction and growth. Deficiency of iodine, inhibits the synthesis of thyroid hormones. As the body senses the lack of thyroid hormones, it produces more and more Thyroid stimulating hormone (TSH). TSH causes the thyroid's gland to grow eventually resulting in a goiter. Goiter in children has been linked to depressed intelligence quotient (IQ), in addition to cold intolerance, weight gain, sluggishness and decreased body temperature. Severe iodine deficiency during early pregnancy causes cretinism. The affected children have stunted growth and are deaf, mute and mentally retarded. The best food sources are seafood, milk and iodized salt. Salt water fish has higher concentration of iodine than fresh water fish. Raw cabbage, turnips, rutabagas and cassava contain compounds known as goitrogens, which are compounds that blocks the body absorption and use of iodine. Consuming large amounts of these foods in their raw form cause problems, cooking however inactivates goitrogens. The daily required value of iodine is 150 μg.

(xi)Copper: Copper also plays a role in various activities including the myelinization of nervous tissue, immune function and cardio-vascular function. Copper is found in a limited variety of foods. The best sources are seafood, legumes and nuts.

(xii)Manganese: Manganese is important to the functioning of several enzymes in the human body. Food sources for manganese are tea, coffee, cereals and some fruits. Pineapple and blackberries are exceptionally good sources of manganese.

(xiii)Fluoride: Fluoride in the body is mainly found in bones and teeth. Bones and teeth contain 99% of the body's fluoride. Fluoride supports mineralization of bone and teeth by promoting the deposition of calcium and phosphate. Fluoride is unique in the sense that its main dietary source is water, not food. Other artificial sources include ready –to-feed infant formulas, fluoride supplements, mouthwash, toothpaste, and some beverages. Low fluoride intake increases the risk of dental caries, and may hamper the integrity of bone. However excess fluoride can cause fluorosis and can weaken teeth.

(xiv)Molybdenum: Molybdenum is essential to both plants and animals. In humans, molybdenum functions as a co-factor for several enzymes that induce oxidation. Good sources of molybdenum include peas, beans and some breakfast cereals.

Fruits and Vegetables

Eat your fruits and vegetables" is one of the tried and true recommendations for a healthy diet. Eating plenty of fruits and vegetables can help you ward off heart disease and stroke, control blood pressure and cholesterol, prevent some types of cancer, avoid a painful intestinal ailment called diverticulitis, and guard against cataract and macular degeneration, two common causes of vision loss. National Cancer Institute (NCI), has sponsored a "5 A Day for Better Health" program to encourage public to include more fruits and vegetables in their diet. Fruits and vegetables contain wealth of nutrient and non-nutrient substances called as phytochemicals that contain protective, disease preventing compounds. More than 900 different phytochemicals have been identified as components of food, and many more phytochemicals continue to be discovered today. It is estimated that there may be more than 100 different phytochemicals in just one serving of vegetables. These popularly known as antioxidants can scavenge or mop off the harmful free radicals produced in the body. Free radicals damage cellular membranes, proteins and DNA and cells and produce a range of diseases in body. Phenols, flavonoids, anthocyanins and carotenoids are some of the important antioxidant found in fruits and vegetables. In this section we will study the nutrient and non-nutrient components of fruits and vegetables.

The edible portion of most types of fruits contains 75-95% of water. Fruits usually are low in calories and with the exception of avocados and olives, contain practically contain no fat. Fruits contain substantial carbohydrates such as fructose, sucrose and starch and are also low in proteins except for tree nuts (walnuts, pecan, pistachio and walnuts). Nutritionally fruits are significant source of vitamin A and C. The vitamin precursor carotene, which is converted in the body to vitamin A, is abundant in mango, papaya, apricots, peaches, cantaloupes and bananas. For vitamin C, citrus fruits guava, papaya, gooseberry and small berry fruits are good sources. Fruits are plentiful in potassium and low in sodium and hence eating fruits helps maintain blood pressure in heart patients. Large amounts of calcium are present in dried fruits and moderate quantities in oranges, raspberries and strawberries. Iron is significant amounts in dates, figs bananas, apricots and raisins. Usually fruits are low in vitamin B, however orange juice is a good source of thiamine and folate. Bananas and watermelon are good source of vitamin B_6.

Vegetables are generally good source of mineral substances in comparison to fruits, which are rich in vitamins. In general vegetables are low in calories except soybean, lima beans, cowpeas, potato and taro, which are abundant in carbohydrates. They are also low in protein except legumes (peas, beans) and low in fat except soybean.

Vegetables are abundant in vitamin A, ascorbic acid, protein (legumes) and fiber. Carrots, sweet potatoes, green leafy vegetables and tomato are best sources of vitamin A among vegetables. Hot chili peppers, squash, turnip greens and spinach are also good sources. Sweet peppers, hot chilies, broccoli, Brussels sprouts and cauliflower and bitter gourd are prominent sources of vitamin C. Vitamin B is found in green peas, lima beans, turnip greens, spinach and sweet potato. Potato is an important source of potassium for people in many countries. Lima beans, soybeans and spinach are good sources of iron. Calcium is present in moderate amounts in turnip greens, soybeans, garlic, parsley and Chinese cabbage. Fruits and vegetables are equally good sources of dietary fiber. We have already seen the importance of dietary fiber in earlier section. Scientific studies have consistently shown that consumption of diets rich in dietary fiber can help reduce the risk of cardiovascular diseases, diverticulosis and colon cancer. A more obvious effect of dietary fiber is their laxative action, which helps relieving of constipation by increasing the water-holding capacity of foods. Vitamin content of some fruits and vegetables is presented in Table 9.

We have earlier pointed out that besides nutrients, fruits and vegetables are also rich in antioxidants. Recent research has shown phenolics, flavonoids and anthocyanins are among the most potent antioxidants found in fruits and vegetables. Red or purple colour of some fruits and vegetables is due to presence of anthocyanin pigment. Consumption of such foods can greatly help reduce the risk of cancer and degenerative Alzheimer disease. Cranberries, blueberries, loganberries are an excellent source of phenolics. In Indian diet, jamun, phalsa, amla, strawberries, pomegranate, apples and plums and black grapes are good sources. Among vegetables, black carrots, red cabbage, red onions and leafy vegetables are excellent sources of phenolics and flavonoids. Lycopene is a carotenoid pigment found in tomatoes, grapefruit, guava and water melon believed to be protective against heart disease and prostrate cancer. Lutein, a yellow pigment found in marigold petals and green leafy vegetables reduces the risk of age related macular degeneration and cataract. Onions and citrus fruits are good for our bones and reduce the risk of osteoporosis in elderly women.

Table 9: Vitamin content in fruits and vegetables

Product	Calorific value (cal/100g)	Vitamin A (IU/100g)	Vitamin B (mg/100g)	Vitamin C (mg/100g)	Nicotinic acid (mg/100g)	Riboflavin (mg/100g)
Fruits						
Apple	56	-	0.03	2	0.2	0.03
Aonla	59	-	0.03	700	0.2	0.03
Banana	153	-	0.04	19	0.3	0.03
Guava	66	-	0.03	300	0.2	0.03
Lime	59	26	0.02	63	0.1	0.02
Mango	50	4800	0.04	24	0.3	0.05
Orange	49	350	0.05	68	0.3	0.06
Papaya	40	2020	0.04	46	0.2	0.05
Pear	47	14	0.02	-	0.2	0.03
Pineapple	50	60	0.03	63	0.2	0.04
Tomato	21	320	0.04	32	0.4	0.05
Leafy Vegetables						
Cabbage	33	2000	0.06	124	0.4	0.12
Drum stick	96	11300	0.06	220	0.8	0.12
Radish leaf	33	6700	0.05	65	0.5	0.12
Spinach	32	5500	0.05	48	0.5	0.11
Roots and Tubers						
Carrot	47	2000-4300	0.04	3	0.4	0.02
Onion	51	-	0.08	11	0.4	0.01
Potato	99	40	0.10	17	1.2	0.01
Radish	21	-	0.06	15	0.4	0.02
Sweet Potato	159	-	0.05	-	0.3	0.01
Yam	79	434	0.06	-	0.7	0.08
Other Vegetables						
Brinjal	34	5	0.05	23	0.8	0.06
Ash gourd	15	-	0.06	5	0.4	0.01
Cauliflower	39	38	0.10	66	0.9	0.08
French been	26	221	0.08	14	0.3	0.06
Cucumber	14	-	0.03	7	0.2	0.02
Lady Finger	41	58	0.06	16	0.6	0.06
Pea	109	139	0.25	9	0.8	0.01
Pumpkin	28	84	0.06	2	0.5	0.04
Snake gourd	22	160	0.04	-	0.3	0.04

Source: NIN, ICMR, Hyderabad, 1999

Pigments and Enzymes

Fruits and vegetables apart from being rich in vitamin and minerals are rich in colour imparting pigments and enzymes. The chief pigments of fruits and vegetables are carotenoids, chlorophyll and anthocyanin. Carotenoids are naturally occurring compounds that give the deep yellow, orange and red colours to fruits and vegetables such as apricots, carrots and tomatoes, orange, capsicum, mango and papaya. Carotenoids also are abundant in dark green vegetables, such as spinach, but the dense chlorophyll marks the carotenoid colours. The major carotenoids found in fruits and vegetables include alpha-carotene, β-carotene, lutein, lycopene and zeaxanthin. The body can convert α-carotene, β-carotene and cryptoxanthin to retinol so they are called pro-vitamin A carotenoids. Lycopene, lutein and zeaxanthin donot have pro-vitamin A activity. Lycopene is the orange- red pigment of tomatoes. Chlorophyll is the green pigment of stem and leaves of plants. Two types of chlorophyll occur in plants, namely Chl a and Chl b in ratio of 3a:1b. Chemically they are similar, and belong to a group of important pigments porphyrins which includes hemoglobin. There is another group of pigments, which are responsible for red, blue and violet color of flowers, fruits and vegetables. These are water-soluble pigments known as anthocyanins. They are usually bonded with carbohydrates such as glucose, galactose and pentose. The color results from the structure of anthocyanidin combined with monosaccharides. The main anthocyanins found in foods include pelargonidin, cyanidin and delphinidin. The red colors of apples, plum black grapes, strawberries, cranberries, phalsa and jamun fruits are due to anthocyanins.

Fruits and vegetables also contain certain specialized chemicals called enzymes. These are important in fruits because of the chemical changes that they initiate. Ficin in figs and papain in papaya are the major proteolytic enzymes. These enzymes can react with proteins of the human skin and cause dermatitis. Phenoloxidases in potatoes, apples, pears, grapes, strawberries, and figs are responsible for the discoloration of cut surfaces when exposed to air. Other enzymes responsible for color changes in fruits and vegetables are chlorophyllases, anthocyanases and peroxidase. Lipoxygenase and lipase are the enzymes associated with off-flavour in frozen peas and beans. Citrus fruits and tomatoes are rich in pectin esterase, and pears and tomatoes in polygalacturonase, both being pectolytic enzymes responsible for softening of fruit texture during ripening.

Processed fruits and vegetables are healthy: Fruits and vegetables are highly perishable in nature because of their high moisture content. They cannot be stored for longer periods and thus there is a need to process them. Processed fruits and vegetables available as canned, frozen, dried and juices are convenient, are available all year round and have a longer shelf life. It is generally believed that fresh fruits and vegetables are always the most nutritious and processed products are inferior. However this is a misconception and fruits and vegetables if processed within hours of harvesting are equally nutritious and healthier than their raw counterparts. Post harvest handling, storage and processing by canning, dehydration, freezing and fermentation do alter the nutrient composition of fruits and vegetables to some extent. Especially, vitamin C and carotenoids are highly susceptible to oxidation and thermal abuse during processing. Losses in nutrients also occur during handling, transportation, storage and retail display; in fact fruits and vegetables, which we consider fresh, reach us after many days after their harvest. However these losses can be minimized if processing takes place immediately after harvest. Canned and frozen fruits and vegetables are good as their fresh counterparts and in some cases even better. Canned produce prepared from freshly harvested produce, maintains majority of the nutrients even though the heating process destroys some vitamins. Similarly frozen vegetables are are equally good as fresh vegetables. Canned tomatoes and tomato sauce have more bio-available lycopene than fresh tomatoes. Similarly, tomato paste has six times higher lycopene than fresh tomatoes. In fresh tomatoes, carotenoids are usually bound to proteins and thus are less bio-available. During thermal processing, heat liberates the bound carotenes from proteineous complex, thus lycopene from processed tomatoes is more readily bio-available in the body. Even cooked carrots are healthier than raw carrots as they contain more antioxidants. Dried fruits also contain greater amounts of nutrients than in the corresponding fresh fruit since they contain only about 13-22% water. Dried fruits are almost devoid of vitamin C, but prunes and dried apricots represent useful sources of phenolic and vitamin A.

Suggested readings

1. Wilson, Eva. D, Katherine, H. Fisher, Mary E. Fuqua (2000) Principles of Nutrition. John Wiley & sons Inc New York, London
2. Paul Insel, R. Eliane, Turner Don Ross (2002) Nutrition Jones and Bartlett publishers Sudbury, Massachusetts
3. Joan, Webster-Gandy (2005). Understanding Food and nutrition (paperback) Family Doctor publications ltd.

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