

BCH 308: FOOD AND NUTRITIONAL BIOCHEMISTRY

Food is the fuel source of the body.

Food additives

Food additives are substances added to food to preserve flavour or enhance taste, appearance or other sensory qualities. Additives are needed to ensure processed food remains safe and in good condition throughout its journey from factories during transportation to shops and finally consumers. They are derived from plants, animals, minerals or synthetic. For example:

Salt as in meat such as bacon or dried fish

Sugar as in marmalade

Sulfur dioxide as in wine.

β -Carotene as in bakery products.

Nutritional additives: used for restoring nutrients lost or degraded during production, fortifying or enriching certain foods in order to correct dietary deficiencies or adding nutrients to food substitutes.

- Iodine in salt for goitre prevention.
- Vitamins added to dairy and cereal products.

Processing agents: agents are added to foods in order to aid processing or to maintain the desired consistency of the product.

- Benzoyl peroxide for bleaching in flour.
- Glycerol for moisture control in soft candies and chewing gums.

Emulsifiers: maintain uniform dispersion of one liquid in another eg oil and water.

- Lecithin as emulsifier in ice cream, mayonnaise and bakery products.

Stabilizers and thickeners: to increase the viscosity of the final products, starches or gums eg gelatin, gums.

Food additives can sometimes cause reactions

- Digestive disorder: diarrhoea
- Nervous disorders: hyperactivity, insomnia and irritability
- Respiratory problems: asthma, sinusitis
- Skin problems: hives, itching, rashes and swelling.

Food Preservatives

Food Preservatives are natural or synthetic chemicals added to food to retard spoilage, whether microbial growth or undesirable chemical damage. Preservatives make food more resistant to microorganisms growth and slows down oxidation in fats and the decomposition and rancidification processes. For example smoked meat has phenols and other chemicals that retard spoilage.

Food preservatives maintain consistency and texture of food, improve or retain nutritional properties and delays damage.

Types of Food Preservatives

Natural — Salt, sugar, alcohol, vinegar, spices
syrup, honey, edible oils.

Chemical — Sorbates, nitrites, benzoates, sulfites
nitrates of sodium and potassium.

Chemical food preservatives have been reported to possibly cause serious health hazards such as hypersensitivity, allergy, neurological damage, and cancer.

Food formulation

Formulation is the process of selecting the kinds and amounts of ingredients to be used in production of a diet containing planned concentration of nutrients. Food formulation is done to access the satiety effect of food.

Adequate nutrition is essential for maintenance of good health for a person of any age or sex. The dietary recommendations are the keys to formulate a new food that provides more than nutrition to the body. Having more concern about living healthy and sustainable, there is huge demand for formulation of food in dairy, spice, fruits, vegetable, Cereals industries by using different technologies that result to rapid economic growth in the food sector. The emerging trends in food industry lead to development of nutraceuticals, food supplements. For example Lactose-free milk, high fibre products, replacement of fats, gluten in bakery products etc. Analytical steps for food formulation to overcome challenges:

- Market analysis
- Product cost and finances
- Trained Personnel.
- Safety assessment
- Ingredients
- Analytical testing
- Manufacturing feasibility.

NUTRITION

Nutrition is the utilization of food by living organisms for health and well being.

Principle of Nutrition

Food been the fuel source of the body undergoes metabolism when ingested to liberate energy required for the vital activities of the body.

Nutrition is divided into ideal nutrition, Undernutrition and overnutrition. Nutrients necessary to support growth and maintenance of living organisms are:

Carbohydrates, proteins, fats, vitamins and minerals
Energy content of foods

The energy content of food is calculated from the heat released by the total combustion of food in a calorimeter. Calorie is the unit of heat. One calorie represents the amount of heat required to raise the temperature of one gram of water by 1°C . Carbohydrates and fats are completely oxidized to CO_2 and H_2O in the body. Proteins are not completely burnt in the body; they are converted to urea, creatinine and ammonia and excreted. Vitamins and minerals have no caloric value though they are involved in the generation of energy from carbohydrates, fats and proteins.

ENERGY UTILIZATION IN MAN

Energy is consumed to meet the fuel demands of Basal Metabolic rate (BMR), specific dynamic action (SDA) and physical activity, others are growth, pregnancy and lactation.

Basal metabolic rate (BMR) is the minimum amount of energy required by the body to maintain life at a complete physical and mental rest in the post-absorptive state. Though the body is at total rest, several functions within the body continuously occur e.g. working of heart, conduction of nerve impulse, gastrointestinal motility and ion transport across membranes. BMR is expressed as Calories per square meter of the body surface area per hour i.e. $\text{Cal}/\text{sq.m}/\text{hr}$.

Factors affecting BMR

- Surface area: BMR is directly proportional to the surface area, which is related to weight and height.

- ~~Sex~~: Men have higher BMR than women due to higher proportion of lean muscle mass in men.
- Age: BMR is higher in infants and growing children, BMR decreases in adults.
- Physical activity: BMR is increased in persons with regular exercise.
- Environment: BMR is higher in cold climates compared to warm climates.
- Starvation: BMR is decreased during the periods of starvation.

Specific dynamic activity is the extra heat production by the body, over and above the Calculated Caloric Value when a given food is metabolized in the body. For the utilization of foods by the body certain amount of energy is consumed from the body stores. Proteins have the highest SDA while Carbohydrates have the lowest. The higher SDA in protein indicates that it is not a good source of energy.

Physical activity of an individual is highly variable. The amount of energy needed for this depends mainly on the duration and intensity of muscular activity. With regards to physical activity and the requirement of energy individuals are grouped into four:

Light work — 30-40%

Moderate work — 40-50%

Heavy work — 50-60%

Very heavy work — 60-100%

The daily requirement of energy is rather variable which depends on BMR and physical activity.

NUTRITIVE VALUE OF FOODS

Nutritional Value of Carbohydrates

Carbohydrates are the main source of energy. They contribute to 60-70% of caloric requirement of the body. They are the most abundant dietary constituents. eg starch, sucrose.

Functions of Carbohydrates

- Major sources of energy: "Principal source of energy"
- Absolute requirement by brain: The brain and other parts of central nervous system are dependent on glucose for energy.
- Required for oxidation of fats
- Non-digestible carbohydrates improve bowel motility, prevent constipation.

Glycemic Index

There are variations in the increase and fall of blood glucose levels after ingestion of different carbohydrate containing foods. These differences are assayed by glycemic index which measure the time course of post-prandial glucose concentration from a graph. Glycemic index is defined as the area under the blood glucose curve after the ingestion of food compared with the area under the blood glucose curve after taking same amount of carbohydrate as glucose.

$$\text{Glycemic Index} = \frac{\text{Area under the blood glucose curve after ingestion of test meal}}{\text{Area under the curve after ingestion of glucose}} \times 100$$

The glycemic index of Complex Carbohydrate is lower than a refined Carbohydrates.

Sources of carbohydrates
Whole grains, Cereals, Dairy products, bread, Sugar.

^{RDA} Requirement of Carbohydrates
At least 40% of the caloric needs of the body should be met from Carbohydrate.

Fibers; are the complex Carbohydrates that are not digested by human enzymes. Fibers are found in fruits, legumes, vegetables and grains.

Function of fiber

- Prevent Constipation.
- Eliminates bacterial toxins
- Improves glucose tolerance.
- Satiety value.

Sources of fiber

Fruits, leafy vegetables, legumes, rice bran.

An average daily intake of about 30g fiber is recommended.

Nutritional value of lipids

Fats and oils are the dietary source of fuel of the body. There are essential fatty acids which are unsaturated fatty acids which the body can not synthesize, therefore must be consumed in the diet. Lipids provide these essential fatty acids and fat soluble vitamins (A, D, E and K). Examples of essential fatty acids are linoleic and linolenic acids.

Functions of essential fatty acids

- They are structural components of biological

membrane.

- Transport and utilization of cholesterol
- Maintain proper growth and reproduction of the organisms.

Sources of essential fatty acids

Vegetable oils such as corn oil, soya bean oil etc

Animal fat such as butter, fat of meat, pork.

RDA

Requirement of dietary fat

At least 30% of dietary fat should come from the essential fatty acids.

Nutritional value of proteins

Proteins are body building foods.

Functions of proteins

- Proteins are the basis of cell structure and its function.
- Enzymes, immunoglobulins and several hormones are all proteins.
- Proteins are involved in maintenance of muscle contraction, clotting of blood, osmotic pressure
- During starvation, proteins serve as major suppliers of energy.

Essential amino acids.

The nutritional importance of proteins is based on the content of essential amino acids. The essential amino acids are Arginine, valine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, tryptophan and threonine.

Non-essential amino acids might become essential in some cases like surgery, healing etc. such as alanine, cysteine, glycine, glutamine, tyrosine.

NITROGEN BALANCE

Dietary protein is a source of nitrogen to the body. Thus nitrogen balance represents the protein utilization and its loss from the body.

$$I = U + F + S$$

I = Intake, U = loss in Urine F = feces, S = Sweat

Positive nitrogen balance: is the state in which the nitrogen intake is higher than the output. It is observed in growing children, pregnant women.

Negative nitrogen balance: situation in which the nitrogen output is higher than input. It is observed in children with Kwashiorkor or marasmus.

Assessment of nutritive value of proteins.

Protein efficiency ration (PER)

PER is represented by gain in the weight of animal per gram protein ingested.

$$PER = \frac{\text{Gain in body weight (g)}}{\text{Protein ingested (g)}}$$

Biological Value (BV)

The biological value of protein is defined as the percentage of absorbed nitrogen retained by the body.

$$BV = \frac{\text{Nitrogen retained}}{\text{Nitrogen absorbed}} \times 100$$

~~Dietary~~ sources of proteins Net Protein Utilization (NPU)
It takes into account the digestibility factor.

$$NPU = \frac{\text{Nitrogen retained}}{\text{Nitrogen ingested}} \times 100$$

Chemical Score (CS)

The ratio between the quantity of most limiting amino acids in the test protein to the quantity of the same amino acid in the egg protein.

$$CS = \frac{\text{mg of the limiting amino acid / g test protein}}{\text{mg of the same amino acid / g egg protein}}$$

Vitamins

Vitamins are organic compounds required in the diet in small amounts to perform specific biological functions for normal maintenance of optimum growth and health of the organism. There are fat soluble (A, D, E and K) and water soluble (C and B group) vitamins.

Functions of Vitamins

- Vitamin A for vision

Vitamin A

Vitamin A is present animal origin and in plants, provitamins, carotenes. Vitamin A function in vision. Vitamin A is essential to maintain healthy epithelial ~~cells~~ tissues.

Sources

Animal Source: Liver, Kidney, egg yolk, milk fish oil are rich in Vitamin A

Vegetables source: Yellow and dark green vegetable fruits are good source of Carotenes eg Carrot, Spinach, mango.

Deficiency of Vitamin A: Night blindness

~~Requirements~~ ^{RDA}: Around 600 μg /day.

Vitamin D

Vitamin D is a fat soluble vitamin. It functions like a hormone. Vitamin D increases the intestinal absorption of Calcium and phosphate. Vitamin D is synthesized in the skin by ultra-violet rays of sunlight.

Sources

Exposure of skin to sunlight, fatty fish, egg yolk etc.

Deficiency of vitamin D: Rickets in children and osteomalacia in adults.

~~Requirements~~ ^{RDA}: 600 IU for adults and 800 IU for older.

Vitamin E (Tocopherol)

Vitamin E is naturally occurring antioxidant. It is essential for normal reproduction in animals. Vitamin E is essential for membrane structure and integrity.

It protect Red blood cells from hemolysis by oxidizing agents. Vitamin E protects liver from being damaged by toxic compounds.

Sources

Many vegetable oils such as peanut oil, Corn oil etc, meat, milk, butter and eggs.

Deficiency of Vitamin E: Sterility, degenerative change in muscle.

^{RDA} Requirements: 10mg for man and 8mg for woman.

Vitamin K

Vitamin K is the only fat soluble vitamin with a specific coenzyme function. It is required for production of blood clotting factors.

Sources

Cabbage, tomatoes, spinach, liver, cheese and dairy products.

Deficiency: leads to lack of clotting factor in the circulation that might lead to increased blood clotting time.

^{RDA} Requirements: 70-100 µg/day.

Vitamin C (Ascorbic acid)

Vitamin C is a water soluble vitamin which plays an important role in human health and disease. Its functions in collagen formation, bone formation, iron and hemoglobin metabolism and preventive action on chronic diseases.

Sources

Citrus fruits, green vegetables, tomatoes.

Deficiency: scurvy which is characterized by spongy and sore gums, loose teeth, anemia, swollen joints etc.

^{RDA} Requirements: 40-50mg/day, 20-40% increase for women during pregnancy and lactation.

Vitamin B group ($B_1, B_2, B_3, B_6, B_{12}$)

B_1 - thiamin, B_2 - riboflavin, B_3 - niacin, B_5 - Pantothenic acid, B_6 - Pyridoxine, B_7 - biotin, B_9 - folic acid and

B₁₂ - Cyanocobalamin.

The B-group vitamins do not provide the body with fuel for energy, they help the body to use the energy yielding nutrients for fuel. They are easily destroyed by alcohol or cooking.

Sources

nuts, legumes, milk, meat, cereals

Deficiencies: Beri-beri, cheilosis (fissures at the corner of the mouth), glossitis (tongue smooth and purplish), dermatitis, pellagra, neurological symptoms (depression), anamia.

^{RDA} Requirements are based on each vitamin and their functions.

Minerals

Mineral elements constitute only a small proportion of body weight. Minerals are essential for calcification of bone, blood coagulation, fluid balance, osmotic regulation. Minerals are classified into principal and trace elements. Principal elements are required in amounts greater than 100mg/day they are: Calcium, Phosphorus, magnesium, sodium, potassium, chloride and sulfur. Trace elements are less required and they are: Iron, zinc, copper, iodine, zinc, manganese, cobalt, selenium, fluoride.

Principal (Macro) elements.

Calcium

Calcium is the most abundant among the minerals of the body. It functions as constituent of bones and teeth, muscle contraction, nerve transmission.

Sources

Milk, leafy vegetables, beans

Deficiency: Rickets, osteomalacia.

^{RDA} Requirement: 0.8 - 1.0g/d in adults.

Phosphorus

Phosphorus is found in every cell of the body. It functions as constituent of bone and teeth, in the formation of nucleic acids, nucleotide coenzymes.

Sources

Milk, Cereal, leafy vegetables

Deficiency: Rickets, osteomalacia

Requirement: 0.8-1.0 g/d.

Magnesium

Magnesium is needed for the formation of bone and teeth, cofactor for coenzymes.

Source

Cereal, fruits, vegetables, milk.

Deficiency: Neuromuscular weakness, irritation.

Requirement: 300-350 mg/d.

Potassium

Potassium is the principal intracellular cation. It functions in acid-base balance, osmotic pressure, muscle function.

Source

Fruits, nuts, vegetables.

Deficiency: Muscular weakness, mental confusion.

Requirement: 3-4 g/d.

Trace (Micro) elements

Iron

About 70% occurs in the erythrocytes of blood as constituent of hemoglobin. Iron functions transport and biological oxidation of oxygen, constituent of heme eg hemoglobin, myoglobin.

Source

Liver, heart, leafy vegetables.

Deficiency: anemia.

Requirement: 10-15 mg/d.

Iodine

Iodine serves as a constituent of thyroxine and triiodothyronine.

Source

Iodized salt, sea foods.

Deficiency: goiter.

~~Requirement~~ Requirement: 150-200 μ g/d.

Zinc

Zinc serve as a cofactor for enzymes.

Source

Meat, fish, milk.

Deficiency: Growth retardation, poor wound healing and hypogonadism.

~~Requirement~~ Requirement: 10-15 mg/d.

Chromium

Chromium function as a glucose tolerance factor therefore promote insulin function.

Source

Meat, whole grains, yeast.

Deficiency: Impaired glucose tolerance

~~Requirement~~ Requirement: 10-100 μ g/d.

Nutritive Value of Water

Water is a substance composed of chemical elements hydrogen and oxygen and existing in gaseous, liquid and solid states. It is a tasteless and odourless liquid at room temperature, it has the ability to dissolve many other substances. Water helps the body lubricate and cushion joints. Get rid of wastes through urination, perspiration and bowel movements.

Source

Rivers, streams, lakes, springs.

Deficiency: Dehydration, fatigue, headache, weakened immunity and dry skin.

~~Requirement~~ Requirement: About 4 liters in men and about 3 liters in women per day.

Recommended dietary allowance (RDA)

The recommended dietary allowances represents the quantities of the nutrients to be provided in the diet daily for maintaining good health and physical efficiency of the body. RDA is not the minimum amount to just meet the body needs, but allowance is given for a safe margin. RDA is also known as ~~minimum~~ boundaries.

Factors affecting RDA

Sex: RDA for men is about 20% higher than that of women. Iron is an exception as the requirement is greater in menstruating women and additional 20-30% in pregnant and lactating women.

Age: The nutrient requirement is higher in the growing age. eg protein requirement for a growing child is about 2g/Kg body wt/day compared to 1g/Kg body wt/day for adults.

RDA of important nutrients for an adult man

weighing 70 Kg

Nutrients	RDA	
Carbohydrates	400g	
Fats	70g	
Proteins	56g	9Kg/m
Essential fatty acids	4g	
Vitamin A	600 μ g	nsidex
Vitamin D	5 μ g	
Vitamin E	10 μ g	
Vitamin K	70 μ g	he
Vitamin B ₁ , B ₂ , C	50 μ g	
Vitamin B ₁ , B ₂ , B ₁₂	1.5mg	
Calcium, phosphorus	800mg	
Iron	10mg	
Vitamin B ₃	15mg	eat)
Vitamin B ₆	2mg	
Vitamin B ₉	200 μ g	cal

BALANCED DIET.

A balanced diet is defined as the diet which contains different type of foods, possessing the nutrients: Carbohydrate, fats, proteins, vitamins and minerals in a proportion to meet the requirements of the body.

The basic composition of balanced diet is highly variable as it differs from Country to Country, depending on the availability of foods. Social and Cultural habits, besides the economic status, age, sex and physical activity of the individual largely influence the intake of diet.

NUTRITIONAL STATUS

The nutritional status of an individual is important in clinical practice. Nutritional status can be defined as the condition of the body as a result of intake, absorption and use of nutrition as well as influence of disease-related factors. The dietary requirements of nutrients are variable and are related to age, sex and physiological status. For example,

- Infants and young children have increased need of protein, iron and calcium.
- At teenage stage, high calcium and magnesium are recommended.
- In pregnancy and Lactation the requirements of iron, calcium, magnesium, folic acid and Vitamin B are increased.
- For elderly people, Vitamin B, folic acid and Vitamin D are recommended.

Nutritional requirement

Nutritional requirement is the amount of each individual nutrient needed to maintain an individual's health. A healthy diet a healthy body and reduces the risk of chronic diseases.

NUTRITIONAL DISORDERS

Nutritional disorders is a nutritional imbalance due to either over nutrition or under nutrition. The disorder is caused by insufficient intake of food or certain nutrients, by inability of the body to absorb and use nutrients, when food is consumed. Examples of some nutritional disorders are; Obesity, Kwashiorkor, Marasmus, Scurvy etc.

Obesity

Obesity is a nutritional disorder characterized by abnormal increase in body weight due to excessive deposition of fat. Obesity results from taking in more calories than are burnt by exercise and normal daily activities. An individual is considered obese if their body weight due to fat exceeds more than 20-25% of body weight, it is also called overeating. Obesity increases the risk of serious health problems.

Obesity can be represented by body mass index.

Body Mass Index (BMI)

Body mass index is calculated as weight (Kg) divided by height (m^2).

$$BMI (Kg/m^2) = \frac{\text{Weight (Kg)}}{\text{Height (m)}^2}$$

Healthy reference range of BMI is 18.5 - 24.9 Kg/m².

Waist hip ratio

The ratio between waist and hip sizes is considered as more effect in representing obesity.

Men < 0.9

Women < 0.85

The lower the waist to hip ratio, the lower the risk for health complications.

Prevention

- Choosing healthier foods (Whole grains, fruits, vegetables).
- Limiting unhealthy foods (refined grains, sweets, red meat)
- Increase physical activity
- Limiting sit time (watching television, screen time) also called sedentary activities.

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Treatment

- Dietary changes
- Physical activity
- Weight-loss medications (Orlistat).
- Surgery

Kwashiorkor

Kwashiorkor is a nutritional disorder caused by an inadequate amount of protein in the diet. Severe protein deficiency can lead to fluid retention which can cause fluid retention that makes the stomach look bloated. Kwashiorkor is mostly common in children, especially after they do not have access to adequate nutrition soon after they stop breastfeeding.

Symptoms such as change in hair color, dehydration, loss of appetite, edema or swelling on legs and feet, finger mark is left when the skin is pressed, loss of muscle and fat tissues are experienced.

Prevention

- Eating enough calories
- Provision of protein-rich foods in diets.

Treatment

- Ingestion of protein-rich foods or its combinations to provide 3-4 g of protein per Kilogram body weight per day will control Kwashiorkor.
- Measurement of plasma albumin concentration can be done to monitor the disorder.
- Monitoring the disappearance of edema and gain in body weight.