# NUTRITION & ESSENTIAL NUTRIENTS – An Overview

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## What is nutrition?

- Utilization of foods by living organisms;
- Areas of Human nutrition:
  - Under-nutrition,
  - Over-nutrition,
  - Ideal or Optimal nutrition

- Major nutrition problems in developing countries:
  - Under-Nutrition: Synonymous with Malnutrition;
  - Nutritional deficiency diseases common among Infants and adults particularly Women;

# What are the major indices of food quality?

- CALORIC VALUE (ENERGY VALUE);
- NUTRITIVE VALUE;

## Units for Caloric Value (Energy Value)

- Kilocalorie (1000 calories ≡ 1.0 Calorie) is the Classical unit of food energy,
- Kilocalorie or Calorie is the amount of heat required to raise the temperature of 1000 grams of water by 1ºC.

- Kilo joule (unit of energy in the SI system),
- 1.0 Kilocalorie ≡ 4.18 KJ of energy.

## What is Caloric Value (Energy Value) of foods and how is it related to Energy Content of food?

**Energy Content of Foodstuff**:

- Determined by burning known quantity of food in a Bomb Calorimeter immersed in water,
- Energy content of food obtained by this method is the same as heat of combustion of the food,
- Amount of energy that the body derives from the food is **less** than the energy content of the food determined in the bomb calorimeter. **WHY??**

**Answer**:

- Energy yielding nutrients (Carbohydrates, Fats and Proteins) are not completely digested;
- Digested fractions are not completely absorbed from GIT,
- Nitrogen atoms in protein cannot be oxidized in the body,

## What is CALORIC (ENERGY) VALUE OF FOOD?

- Amount of calories (energy) derived from the food or expected to be derived from the food by the BODY,
- **Is caloric value (energy value) of a food the same as the Energy content of the food?**
- **Answer: No it is not. Why??**
- By definition: **Caloric (Energy) Value** equals:

  **ENERGY Content – ENERGY Loss during digestion**

- **ENERGY CONTENT IS ALWAYS HIGHER THAN CALORIC (ENERGY) VALUE OF FOODSTUFFS;**

# How can Energy value of food be calculated?

- By convention Energy value of food is calculated from Macronutrient (Carbohydrate, Fat and Protein) content of the food,
- For foods containing alcohol, the amount of alcohol in the food must be included in the calculation,
- If the amount of Protein, Carbohydrate and Fat are known, then Energy Value of the food can be calculated from an equation:

**Energy Value (Kcal) = (P x p) + (F x f) + (C x c)**

- Where: **P, F** and **C** represents the amounts (expressed in grams) of **Protein, Fat** and **Carbohydrate**, respectively, in the food as determined by chemical analysis or obtained from the Food Composition Tables
- Where: **p, f** and **c**, denotes the energy conversion factors (i.e. **ATWATER Energy Factors**) for Protein, Fat and Carbohydrate respectively,

# What are Atwater Energy Factors?

- **Atwater Energy Factor expresses the energy value of 1.0g of the respective Macronutrient,**
- **Atwater Energy Factors permit calculation of Metabolizable Energy of mixed diet and foodstuffs with considerable degree of accuracy,**
- The respective Atwater energy factors are:
- **1.0g Protein is equivalent to 4.0Kcal of energy,**
- **1.0g Fat is equivalent to 9.0Kcal of energy,**
- **1.0g Carbohydrate is equivalent to 3.75Kcal of energy,**
- **1.0g Alcohol is equivalent to 7.0Kcal of energy,**

# How is the metabolizable energy of a diet calculated?

**Question**:

- Calculate the metabolizable energy of a diet containing 25.0g dietary protein, 10.0g dietary fat, 120.0g available carbohydrates and 3.0g ethanol.
- If the heat of combustion (Energy content) of the diet is 1000.0 Kcal, what percentage of its energy content is available to the body?

# ANSWERS

**Atwater factors** are:

- Protein = 4.0Kcal/g;
- Fat = 9.0Kcal/g;
- Carbohydrate = 3.75Kcal/g;
- Ethanol = 7.0Kcal/g;

- Energy value of dietary Protein = 25 x 4 = 100Kcal,
- Energy value of dietary Fat = 10 x 9 = 90Kcal,
- Energy value of dietary Carbohydrate = 120 x 3.75 = 450Kcal,
- Energy value of dietary Ethanol = 3 x 7 = 21Kcal,

**Total Energy value = 100 + 90 + 450 + 21 = 661Kcal**

Thus, **Metabolizable Energy of the diet = 661Kcal**

## Answer cont....

- Percentage of energy available to the body is calculated as follows:

$$\frac{\text{Metabolizable Energy}}{\text{Heat of combustion}} \times 100\%$$

$$\frac{661}{1000} \times 100 = 66.1\%$$

- **% of energy content available to the body = 66.1%**

# NUTRITIVE VALUE OF FOODS

**What is the nutritive value of food?**

- Nutritive value of a food is the **amount of nourishment** that is actually **derivable** from the food;

**Is nutritive value of food the same as nutrient composition of food?**

- Nutritive value of food is not the same as nutrient composition of food,
- Nutrient compositions of most major foodstuffs have been determined and the data are available as food composition Tables and in databases;

## IMPORTANT TO NOTE

- Food composition tables are not standards,
- Nutrients values of foods are usually specific for regions/countries, because of crop varieties and the nutrient composition of the soil on which the crops or foodstuffs were grown,
- Quality of an animal food source also depends on the feeds given to the livestock,
- A major significance of food composition Table is that it facilitates easier comparison of nutrient contents of different foodstuffs; it makes it easier to select a mixture of foodstuffs to meet the nutrient requirements of selected diets

# What are the major Essential Macronutrients?

- **Dietary Essential Amino Acids (EAA)**:
- Amino acids that cannot be synthesized in the body, they must be obtained from protein in the diet. They are:
  - **For healthy infants: TV TILL PM,**
  - **PVT TIM HALL (used for Albino rats)**
- Cysteine and Tyrosine may be formed from Methionine and Phenylalanine respectively,
- Thus, if sufficient amount of Cysteine and Tyrosine are present in the diet, they spare the dietary requirement for Methionine and Phenylalanine,

Eight (8) EAA for healthy Infants **(TV TILL PM)**

- **Threonine (T)**
- **Valine (V)**
- **Tryptophan (T)**
- **Isoleucine (I)**
- **Leucine (L)**
- **Lysine (L)**
- **Phenylalanine (P)**
- **Methionine (M)**

**For Premature Infants**: **Nine EAA** are required:

**A TV TILL PM**

- **A = Arginine** (produced in the Urea Cycle)
- Important in premature infants because urea cycle is not functional

## Dietary Essential Fatty Acids?

Polyunsaturated Fatty Acids that cannot be synthesize in the body; Examples:

- **Omega-6 fatty acids:**
  - Linoleic Acid and Arachidonic Acid;
  - Arachidonic acid: semi-essential fatty acid because it can be synthesized from Linoleic or Linolenic acid;
- **Omega-3 fatty acids:**
  - Linolenic Acid,
  - Timnodonic acid (EPA),

## What is “Protein Quality” or “First Class” Protein?

- Egg and Milk proteins are considered as “**High-quality**” or **“First Class” Proteins** because:
- They contain all the Essential Amino Acids in biologically available forms and in proportions required for adequate nutrition;
- They are efficiently utilizes in the body;
- They are used as reference standards against which other proteins are compared;

## How is the quality of a protein assessed?

- Quality of a protein is assessed by comparing the proportions of Essential Amino Acids in the protein with the proportions in a standard or reference protein, such as Egg or Milk protein;

- The closer the proportions are the higher the protein quality;

## Why is the biological value of plant proteins zero?

- **Plant proteins** are relatively low quality proteins, because they are usually deficient in one or more Essential Amino Acids: Examples:
- Maize (corn): deficient in Tryptophan and Lysine;
- Wheat, other Cereals: deficient in Lysine;
- Rice: deficient in Lysine;
- Beans: deficient in Valine;
- Soybeans: deficient in Methionine;
- Potatoes: deficient in Leucine;
- Cassava: deficient in Methionine

- Deficiency of an essential amino acid in a given protein can be made up by the abundance of that essential amino acid in another protein in a mixed diet;
- Phenomenon known as Complementary; **Example**:
- A diet made up of Cereals and Soybeans mixed together provides a satisfactory intake of all the essential amino acids;
  - Lysine deficient in Cereals
  - Methionine deficient in Soybeans

# What is protein sparing effect (Protein to energy ratio)?

- Carbohydrates supply energy for body function,
- Fats supply the bulk of the body's energy needs,
- Dietary protein is mainly used for tissue building and repair,
- Protein can serve as a significant source of energy only when dietary carbohydrates and fats are not sufficient to meet the body's needs,
- **As the energy (calorie) value of the diet from carbohydrate and fat increases, the need for protein decreases:**
  - **Phenomenon called: PROTEIN-SPARING EFFECT**
- **Carbohydrate is more efficient at Protein Sparing than fat, because most tissues can use carbohydrate as substrate for energy production;**

## NON-NUTRIENTS: (DIETARY FIBERS):

**What are the major Non-nutrients?**

- Major non-nutrients with beneficial effects are Dietary Fibers (Roughage);

**What are Dietary Fibers?**

- Dietary fibers are non-nutrient component of food that cannot be broken down by human digestive enzymes;
- Non-starch polysaccharide and Lignin, which includes cellulose, and non-cellulose polysaccharides;
- Bacterial enzymes in our GIT can breakdown some dietary fibers;

## What are some of the biological effects of dietary fiber?

- Dietary fiber has a laxative effect on the GIT;
- Dietary fiber increases fecal bulk;
- Dietary fiber lowers plasma cholesterol level;
- Dietary fiber decreases nutrient availability;
- Dietary fiber reduces Glycemic response to carbohydrate–containing meals;
- Low intake of dietary fibers is implicated in:
  - Cancer of Colon and Rectum;
  - Diverticular disease of the Colon;
  - Hemorrhoid;
  - Appendicitis;

## Non-nutrients  in that affect bioavailability of nutrients

- OXALIC ACID:
  - forms Oxalate precipitate with dietary Calcium;
- PHYTIC ACID:
  - forms insoluble Phytates with Ca, Fe, Zn and other divalent metals;
- TANNINS (Tannic Acid):
  - forms insoluble complex with Ca, Fe, Zn and other divalent metals;
- PROTEINASE INHIBITORS:
  - Inhibits digestion of proteins in the GIT;
- AVIDIN: Inhibits biosynthesis of fatty acids;

# MICRONUTRIENTS: VITAMINS AND MINERALS

- Micronutrient deficiency: Vitamin and Mineral Deficiency (VMD): widespread among Women and Children in resource limited countries;
- Individuals with multiple deficiencies are in a state of Micronutrient Starvation,
- They suffer from "**Hidden Hunger**" that secretly suppresses their immune response, increasing the risk of developing infectious diseases,

- Adequate amount of Micronutrients are needed at all ages,
- Effects of Inadequate Intake are serious during periods of Rapid Growth, Early Childhood, Pregnancy and Lactation;

- **Iron, Zinc, Iodine and Selenium** among others are very important for Physical and Cognitive development of children;

# MINERAL ELEMENTS

**What are the two major groups of dietary mineral elements?**

- **Macroelements:** required in amounts greater than 100 mg per day
  - Example: Calcium, Magnesium

- **Microelements** or **Trace Elements:** required in amounts less than 100 mg per day;
  - Examples: Iron, Iodine, Zinc, Selenium

## How important is Iodine?

- Iodine is essential for biosynthesis of Thyroid hormones:
  - Thyroxine (T 4)
  - Tri-Iodothyronine (T 3)

- **Iodine Deficiency (ID) is regarded as the single most common cause of preventable mental retardation and brain damage in a population where the intake of iodine is insufficient;**

- Severe ID that leads to Endemic Cretinism has been reduced World-wide because of implementation of dietary iodine supplementation programs {**Universal Salt Iodization** (USI) strategy};

- In women of childbearing age: ID can cause: Infertility and set the stage for Miscarriage, Abortion, or Stillbirth during pregnancy

- Maternal ID can compromise the Thyroid status of the Fetus and Neonate;

- Fetal Neurodevelopment is most vulnerable to damage during early gestation in women with Mild to Moderate ID;

- Maternal milk is the major source of Iodine for Neonates

## WATER SOLUBLE VITAMINS

- Most of them (Coenzymes) helps enzymes to work;
- Most are of plant origin, with the exception of Vitamin $B_{12}$, which is found mainly in foods of animal origin;
- Vegetarians and others, who avoid animal foods, should include a source of Vitamin $B_{12}$ in their diet, either as a supplement or as fortified foods

| Common names | Metabolic functions | Some common sources |
|---|---|---|
| **Vitamin $B_1$** (Thiamine) | Cofactor for some enzymes in the body | Fruits, Nuts, Vegetables, Eggs, Meat, Fish, Milk, Vitamin enriched rice in Papua New Guinea (PNG) |
| **Vitamin $B_2$** (Riboflavin) | Cofactor for some enzymes in the body | Fruits, Nuts, Vegetables, Eggs, Meat, Fish, Milk, Vitamin enriched rice in |
| **Vitamin $B_3$** (Niacin: Nicotinic Acid; Nicotinamide) | Cofactor for some enzymes in the body | Fruits, Nuts, Vegetables, Eggs, Meat, Fish, Milk, Vitamin enriched rice in PNG |
| **Vitamin $B_5$** (Pantothenic Acid) | Formation of Coenzyme-A (CoA) | Fruits, Nuts, Vegetables, Eggs, Meat, Fish, Milk, |
| **Vitamin $B_6$** (Pyridoxine,Pyridoxal) | Cofactor for some enzymes in the body | Fruits, Nuts, Vegetables, Eggs, Meat, Fish, Milk |
| **Vitamin $B_{12}$** (Cobalamin) | Cofactor for production of DNA which is important for normal formation and functions of cells | Eggs, Meat, Fish, Dairy; may be synthesize by some microorganisms in our gastrointestinal tract (GIT) |
| **Vitamin M** Folic Acid, Folate | Cofactor for production of DNA and RNA; works together with Vitamin $B_{12}$ | Eggs, Meat, Fish, Dairy, Nuts, Fruits, Vegetables |
| **Vitamin C** Ascorbic Acid | Cofactor for synthesis of Collagen; Important for digestion of dietary Iron; Anti-oxidant; | Fruits (mainly citrus), Vegetables, Nuts, Grains, Seeds |
| **Biotin** | Cofactor for Carboxylation reactions | Eggs, Liver, Fish, Nuts, Seeds, Grains |

# FAT SOLUBLE VITAMINES

| Common names<br>Fat soluble vits | Metabolic functions | Some common sources |
|---|---|---|
| **Vitamin A**<br>(Retinol) | • Growth differentiation of cells;<br>• Formation of visual pigments (especially for night vision);<br>• Normal function of immune system (formation of Mucin in mucus membrane); | Fruits, Vegetables, Nuts |
| **Vitamin $D_3$**<br>(Cholecalciferol) | • Absorption of Calcium GIT,<br>• Reabsorption & Mobilization of Calcium and Phosphate in Bone | Can be synthesize from Cholesterol (involves the liver, sun exposed skin, kidneys);<br>Fortified dairy products; |
| **Vitamin E**<br>(Tocopherols) | Antioxidants protecting polyunsaturated fatty acids in membranes, | Grains, Nuts, Seeds, Vegetables (especially green leafy); |
| **Vitamin K**<br>(Phytomenadione) | Required for formation of clotting factors;<br>Normal clotting of blood; | Produce by bacteria in our GIT |

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