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 1°C.
• 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:

  \[ \text{Energy Value (Kcal)} = (P \times p) + (F \times f) + (C \times c) \]
• 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?
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 \times 4 = 100\text{Kcal},
- Energy value of dietary Fat = 10 \times 9 = 90\text{Kcal},
- Energy value of dietary Carbohydrate = 120 \times 3.75 = 450\text{Kcal},
- Energy value of dietary Ethanol = 3 \times 7 = 21\text{Kcal},

Total Energy value = 100 + 90 + 450 + 21 = 661\text{Kcal}

Thus, Metabolizable Energy of the diet = 661\text{Kcal}
• Percentage of energy available to the body is calculated as follows:

\[
\text{Metabolizable Energy} \quad \frac{\text{Heat of combustion}}{1000} \times 100 = 66.1\% \\
\]

• \% 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;
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;
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
<table>
<thead>
<tr>
<th>Common names</th>
<th>Metabolic functions</th>
<th>Some common sources</th>
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<tbody>
<tr>
<td>Vitamin B&lt;sub&gt;1&lt;/sub&gt; (Thiamine)</td>
<td>Cofactor for some enzymes in the body</td>
<td>Fruits, Nuts, Vegetables, Eggs, Meat, Fish, Milk, Vitamin enriched rice in Papua New Guinea (PNG)</td>
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<tr>
<td>Vitamin B&lt;sub&gt;2&lt;/sub&gt; (Riboflavin)</td>
<td>Cofactor for some enzymes in the body</td>
<td>Fruits, Nuts, Vegetables, Eggs, Meat, Fish, Milk, Vitamin enriched rice in PNG</td>
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<tr>
<td>Vitamin B&lt;sub&gt;3&lt;/sub&gt; (Niacin: Nicotinic Acid; Nicotinamide)</td>
<td>Cofactor for some enzymes in the body</td>
<td>Fruits, Nuts, Vegetables, Eggs, Meat, Fish, Milk, Vitamin enriched rice in PNG</td>
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<td>Vitamin B&lt;sub&gt;5&lt;/sub&gt; (Pantothenic Acid)</td>
<td>Formation of Coenzyme-A (CoA)</td>
<td>Fruits, Nuts, Vegetables, Eggs, Meat, Fish, Milk</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;6&lt;/sub&gt; (Pyridoxine, Pyridoxal)</td>
<td>Cofactor for some enzymes in the body</td>
<td>Fruits, Nuts, Vegetables, Eggs, Meat, Fish, Milk</td>
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<td>Vitamin B&lt;sub&gt;12&lt;/sub&gt; (Cobalamin)</td>
<td>Cofactor for production of DNA which is important for normal formation and functions of cells</td>
<td>Eggs, Meat, Fish, Dairy; may be synthesize by some microorganisms in our gastrointestinal tract (GIT)</td>
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<tr>
<td>Vitamin M Folic Acid, Folate</td>
<td>Cofactor for production of DNA and RNA; works together with Vitamin B&lt;sub&gt;12&lt;/sub&gt;</td>
<td>Eggs, Meat, Fish, Dairy, Nuts, Fruits, Vegetables</td>
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<td>Vitamin C Ascorbic Acid</td>
<td>Cofactor for synthesis of Collagen; Important for digestion of dietary Iron; Anti-oxidant;</td>
<td>Fruits (mainly citrus), Vegetables, Nuts, Grains, Seeds</td>
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<tr>
<td>Biotin</td>
<td>Cofactor for Carboxylation reactions</td>
<td>Eggs, Liver, Fish, Nuts, Seeds, Grains</td>
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<td>Common names Fat soluble vits</td>
<td>Metabolic functions</td>
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| **Vitamin A** *(Retinol)*    | • Growth differentiation of cells;  
                              • Formation of visual pigments (especially for night vision);  
                              • Normal function of immune system (formation of Mucin in mucus membrane); | Fruits, Vegetables, Nuts |
| **Vitamin D₃** *(Cholecalciferol)* | • Absorption of Calcium GIT,  
                              • Reabsorption & Mobilization of Calcium and Phosphate in Bone | Can be synthesize from Cholesterol (involves the liver, sun exposed skin, kidneys); Fortified dairy products; |
| **Vitamin E** *(Tocopherols)* | Antioxidants protecting polyunsaturated fatty acids in membranes, | Grains, Nuts, Seeds, Vegetables (especially green leafy); |
| **Vitamin K** *(Phytomenadione)* | Required for formation of clotting factors;  
                              Normal clotting of blood; | Produce by bacteria in our GIT |
References


4. WHO; Nutrition and HIV/AIDS: Report by the Secretariat. 59th World Health Assembly; Provisional Agenda Item 11.3; A59/7, May 2006.