

## **Nutritional Additives**

- Include vitamins, minerals and amino acids
- Added in the food:
  - To correct a recognized deficiency of one or more nutrients in the diet (Fortification)
  - To maintain the nutritional quality of the food supply to ensure good health (enrichment)

## **Vitamins**

- The term vitamin is derived from the words vital and amines, because vitamins are essential for human life and were originally thought to be amines.
- Classified into two groups: fat soluble and water soluble
- Vitamins are required in only trace quantities in the diet
- They are essential for growth, maintenance and metabolic processes within the body.

## **Fat Soluble Vitamins**

### **Vitamin A**

- Vitamin A is a generic term for a number of related compounds.
- Retinol (alcohol) and retinal (aldehyde) are often referred as preformed vitamin A. Retinal can be converted by the body to retinoic acid, the actual form of vitamin A.
- Retinol, retinal, retinoic acid, and related compounds are called retinoids.
- Beta-carotene and other carotenoids that can be converted by the body into retinol are referred to as pro-vitamin A.
- In body, vitamin A is required for growth, development, good vision, regulation of gene expression, immunity and reproductive ability.
- Its deficiency causes night blindness, skin keratinization and retarded growth in children.
- Vitamin A is strictly found in human, animal, fish and avian tissues as well as in some related products such as eggs, milk and milk products.
- Since it is stored in the liver, this organ is a particularly good source of vitamin A.
- Excessive intake has no adverse effects on human.

### **Vitamin D**

- Fat-soluble vitamin essential for normal calcium metabolism.
- Vitamin D<sub>3</sub> (Cholecalciferol) is synthesized by human in the skin from cholesterol upon exposure to ultraviolet radiation from sunlight.

- Plant synthesizes vitamin D<sub>2</sub> (ergocalciferol), which also has vitamin D activity in human.
- Deficiency of this vitamin leads to rickets characterized by softening of bones in children while causes osteomalacia and osteoporosis in adults.
- Fish liver oils are generally good sources of this vitamin.
- It is sensitive to heat, light and air.
- Excessive intake of vitamin D raises the concentration of blood calcium that results in calcification of soft tissues such as heart, lungs and kidneys.

### **Vitamin E**

- The term vitamin E is comprised of a family of eight isomers, four tocopherols (alpha, beta, gamma and delta) and four tocotrienols (also alpha, beta, gamma and delta).
- Alpha tocopherol is the only form of vitamin E that is actively maintained in the human body.
- They are particularly high in some plant products, notably vegetable oils and wheat germ.
- Vitamin E is commercially available as an acetate ester and also as a succinate ester to protect from oxidation during storage.
- On ingestion, they are de-esterified by intestinal enzymes soon after absorption to form alpha-tocopherol.

### **Vitamin K**

- Fat-soluble vitamin.
- The “K” is derived from the German word “koagulation”, refers to blood clotting, because vitamin K is essential for the functioning of several proteins involved in thrombosis (formation of blood clot in blood vessels).
- There are two naturally occurring forms of vitamin K
  - K<sub>1</sub> Phylloquinone: synthesize by plants
  - K<sub>2</sub> Menaquinone: synthesize by bacteria
- Good sources of vitamin K<sub>1</sub> are green leafy vegetables.
- Heat stable and oxygen-resistant but liable to degrade when expose to light.

## **Water Soluble Vitamins**

### **Vitamin C**

- Also known as ascorbic acid
- Unlike most mammals, humans have no capacity to synthesize vitamin C.
- The last enzyme required in its biosynthesis, L-gulonolactone oxidase, cannot be formed because gene for this enzyme is defective in humans.
- Therefore, one must obtain vitamin C through the diet.
- Two compounds contain vitamin C activity, ascorbic acid and its partially oxidized form dehydroascorbic acid.
- Ascorbic acid is a six carbon compound that is synthesized in nature and commercially produced from glucose.
- Rich sources of this vitamin are black current, mango, guava, citrus products, and some vegetables such as broccoli, cauliflower, green pepper and tomatoes.
- Ascorbic acid is readily oxidized in air and it is heat-labile. It can be lost from food due to leaching.
- Vitamin C is commercially available in powder or granular form as L-ascorbic acid or its sodium salt and as L-ascorbic stearate and nictotinamide ascorbic acid complex.
- Ascorbic acid is relatively non-toxic.

### **Vitamin B-Complex**

#### **Thiamine**

- It occurs in the human body as free thiamin and in various phosphorylated forms such as thiamine pyrophosphate, thiamin monophosphate and thiamin triphosphate.
- Thiamin is an antiberiberi factor.
- Excessive consumption of raw fish, because of the presence of enzyme thiaminase and the use of large amount of tea, which contains a thiamin antivitamin factor, may also results in its deficiency.
- Richest source of thiamin are organ meat, lean meat, yeast, eggs, legumes, whole and enriched wheat products, as well as unpolished rice.
- Thiamin is commercially available as thiamin hydrochloride and thiamin nitrate.
- Sometimes high oral doses can result in gastric upset.

## **Riboflavin**

- Water soluble, B<sub>2</sub>.
- In the body, riboflavin is primarily found as an integral component of the co-enzyme, flavin adenine dinucleotide (FAD) and flavin mononucleotide (FMN).
- In its coenzyme forms, it is involved in electron transfer in biological oxidation-reduction system.
- Some of the deficiency symptoms include photophobia, burning of the eyes, lips and tongue, visual fatigue and loss of visual activity.
- Good sources are milk and dairy products, organ meat, eggs, fish, leafy vegetables, legumes and whole grains.
- Sensitive to light.
- Riboflavin is available as riboflavin, riboflavin phosphate, riboflavin-5-phosphate ester, riboflavin butyrate and sodium riboflavin phosphate.

## **Niacin**

- Water-soluble.
- Also known as nicotinic acid, vitamin B<sub>3</sub> and vitamin PP (Pellagra preventing).
- Nicotinamide is the derivative of niacin and used by the body to form the coenzyme nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP).
- Good sources of this vitamin are liver, meat, poultry, fish, legumes, cereals, potatoes and nuts.
- The vitamin is very stable to heat and oxidation.

## **Vitamin B<sub>6</sub>**

- Six forms which exhibit vit. B<sub>6</sub> activity are pyridoxal, pyridoxine, pyridoxamine and their derivatives including pyridoxal-5-phosphate, pyridoxine-5-phosphate and pyridoxamine-5-phosphate.
- Pyridoxal-5-phosphate is the active coenzyme form and is the most important in human metabolism.
- Pyridoxine is the only B<sub>6</sub> vitamin that is used commercially as an additive. B<sub>6</sub> is relatively non-toxic.
- Vitamin B<sub>6</sub> found in liver, meat, poultry, fish, legumes and some vegetables, notable broccoli, cauliflower, potatoes, spinach and sweet corn.
- Among fruits, bananas and avocados are the good sources.

## **Vitamin B<sub>12</sub>**

- Also known as cyanocobalamin.
- It is unique among vitamins in that it contains a metal ion, cobalt.
- Methylcobalmin and 5-deoxyadenosyl cobalamin are the forms of vitamin B<sub>12</sub> present in the human body.
- Deficiency results pernicious anemia.
- Found strictly in animal sources.
- Appears to be no hazard to human.

## **Amino acids**

- Amino acids play a central role both as building blocks of proteins and as intermediates in metabolism.
- 20 amino acids.
- Human can synthesize 11 of the 20 amino acids.
- The amino acids that can be produced in the human body are alanine, arginine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, proline, serine and tyrosine.
- Tyrosine is produced from phenylalanine, so if the diet is deficient in phenylalanine, tyrosine will be required as well.
- The essential amino acids are histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine.
- The lysine is low in wheat, corn, oat and rice while methionine in peas, potatoes, soybean, beef and milk, tryptophan in corn, casein and rice while threonine in wheat, rye and fish. Considering their daily requirement, the foods are fortified with deficient amino acids.

## **Minerals and Trace elements**

- Minerals are elements that originate from the earth and cannot be made by living organisms.
- Plants obtain minerals from the soil, and most of the minerals in our diet come directly from plants or indirectly from animal sources.
- Minerals may also be present in the water which we drink, but this varies with geographic location.
- Three minerals (calcium, magnesium and phosphorus) and six trace elements (copper, iron, manganese, zinc, fluorine and iodine) are the most commonly used essential elements as nutritional food additives.

## **Calcium**

- About 99% of the calcium in the body is found in bones and teeth, while the rest 1% is found in the blood and soft tissues.
- Calcium level in the blood and fluid surrounding the cells (extracellular fluid) must be maintained within a very narrow concentration range for normal physiological functioning.
- The physiological functions of Ca are so vital for survival that the body will demineralize bone to maintain normal blood calcium levels when calcium intake is not sufficient.
- Calcium is required for bone formation and its deficiency caused the development of rickets in children.
- Insufficient intake of this mineral has been linked to high blood pressure.
- The various forms of calcium permitted to be used in foods as a nutritional additive include calcium carbonate, ground limestone, calcium chloride, calcium citrate, calcium glycerolphosphate, calcium hydroxide, calcium oxide, calcium phosphate, calcium pyrophosphate and calcium sulfate.

## **Phosphorus**

- Approximately 85% of the body's phosphorus is found in bones.
- The US RDA for the phosphorus has been set at 1g.
- The following forms of phosphates are permissible for use in foods: sodium and potassium phosphate, tetrapotassium and tetra sodium pyrophosphates, glycerophosphates and hexametaphosphate.

## **Magnesium**

- The adult human body contain about 25 g magnesium.
- Over 60% of all the magnesium in the body is found in skeleton, about 27% in muscle, 6-7% in other cells, and less than 1% in extracellular fluid.
- Deficiencies of this mineral are rare except under pathological conditions.
- Mg deficiency can lead to cardiovascular damage.

## **Iron**

- In human, iron is an essential component of hundreds of proteins and enzymes in the body.
- It is found primarily in hemoglobin in red blood cells and in myoglobin, a muscle protein, as well as in some enzymes.
- Its major function is oxygen transport.
- Iron deficiency results in anemia.

- Phytic acid, fibers, phosphates, polyphenols, some proteins and organic acids can adversely affect iron absorption.
- The following iron compounds have been approved for use as nutritional additives: ferrous sulfate, ferrous gluconate, ferrous lactate, ferric choline citrate, ferrous fumarate, ferric orthophosphate, ferric pyrophosphate, sodium iron pyrophosphate and reduced elemental iron.

## **Iodine**

- Required for the synthesis of thyroid hormones.
- Most of the earth's iodine is found in oceans.
- Deficiency of iodine leads to thyroid enlargement or goiter.
- The following compounds are recognized sources of iodine: potassium iodine and cuprous iodide.

## **Applications**

### **1. Dairy Products**

- Addition of Vitamin A and D are both optional for acidified low fat milk, cultured low fat milk, acidified skim milk and cultured skim milk.
- Vitamin A and D are required to be added to evaporated skim milk.
- Fortification is not permitted for sweetened condensed milk, sweetened condensed skim milk and for various forms of cream.

### **2. Cereal grains**

- During milling of cereals, loss of vitamins occur especially thiamine, riboflavin and niacin along with iron. To make up these deficiencies there are set standards of the codex.
- Food receiving severe heat treatment during processing should preferably be fortified with Vitamin A after heating. The Vitamin A can be added by spraying an oil/water emulsion on the surface of the cooked product e.g. breakfast cereals.
- Wheat is deficient in lysine. To handle this deficiency wheat flour and its products are fortified or enriched with lysine.

### **3. Margarine**

- Need the addition of Vit A. Addition of vitamin D is optional.

#### **4. Salt**

- Iodine may be added.

#### **5. Infant formulations**

- The main purpose of adding amino acids in foods is to supplement those amino acids that are deficient from the proteins in a particular food. The amino acid related compound taurine, which is formed by decarboxylation of cysteic acid, an oxidative product of cysteine is used in some infant recipes and designated as duplicate mother's milk.
- Vitamin E, linoleic acid, vitamin B6, vitamin K in the form of phylloquinone, calcium and phosphorus can be added in infant foods.