

UNIT 2

NUTRITIONAL DISORDERS: WATER SOLUBLE VITAMINS

Structure

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2.3	Vitamins: Nutritional Deficiency Diseases-	Kwashiorkor
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2.1 INTRODUCTION

You have learned about balanced diet, RDA, dietary nutrients in Unit 1, In addition to major dietary nutrients (carbohydrates, proteins and lipids), our body also requires a variety of organic substances in smaller amount known as vitamins which are necessary for normal function of cells, body's growth, metabolism of nutrients and reproduction. Various diseases such as beriberi, pellagra, pernicious anemia and scurvy can occur as a result of water soluble vitamin deficiency in diet. Vitamins are used to treat vitamin deficiency diseases as therapeutic agents. Hence, vitamin rich food is required to include in our daily diet.

Therefore, in this unit, you will learn the biochemical function and nutritional disorders and biochemical function water soluble vitamin deficiency diseases and their causes, symptoms and biochemical aspect in human health. You will also learn about causes and symptoms of malnutrition diseases such as kwashiorkor and marasmus.

Expected Learning Outcomes

After studying this unit, you should be able to:

- ❖ define the vitamins and their importance in life;
- ❖ describe the vitamin deficiency diseases;
- ❖ state the malnutrition;
- ❖ explain causes and symptoms of kwashiorkor and marasmus;
- ❖ discuss biochemical consequences of vitamin deficiency and malnutrition;
- ❖ enlist the common dietary sources and recommended daily allowance (RDA) of vitamins.

2.2 WATER SOLUBLE VITAMINS

Recall the chemical nature and biochemical functions of different vitamins discussed in the Unit 12 Vitamins 1st semester course of Biomolecules (BBCCT101). The Polish-American biochemist, Casmir Funk coined the term "vitamins." Vitamins are organic compounds present naturally in natural foods are considered to be necessary food factors in human as well as animal nutrition. As they cannot be synthesized by the body with the exception of vitamin D, they must be obtained from dietary sources or supplements.

On the basis of solubility, vitamins are divided into two major categories (Fig. 2.1):

1. Water-soluble vitamins and
2. Fat-soluble vitamins.

Water soluble vitamins are of two types: vitamin B-complex and vitamin C. The thiamin (vitamin B₁), Riboflavin (vitamin B₂), niacin, Biotin, Pyridoxin (vitamin B₆), pantothenic acid, Folic acid and Cobalamin (vitamin B₁₂) are the member of the B complex vitamins.

Water soluble vitamins share the following characteristics: These vitamins are soluble in water, readily absorb in the body, do not accumulate in the body, and do not often cause toxicity due to overdose. They also serve as cofactors in enzyme catalysis. Water-soluble vitamins are easily excreted in the urine as they do not store in the body.

Enzymes require cofactors to work, and many enzymes are optimally active only when cofactors (Coenzyme) are present. Most of these cofactors (Coenzyme) are derived from water-soluble vitamins, and each vitamin performs a unique function.

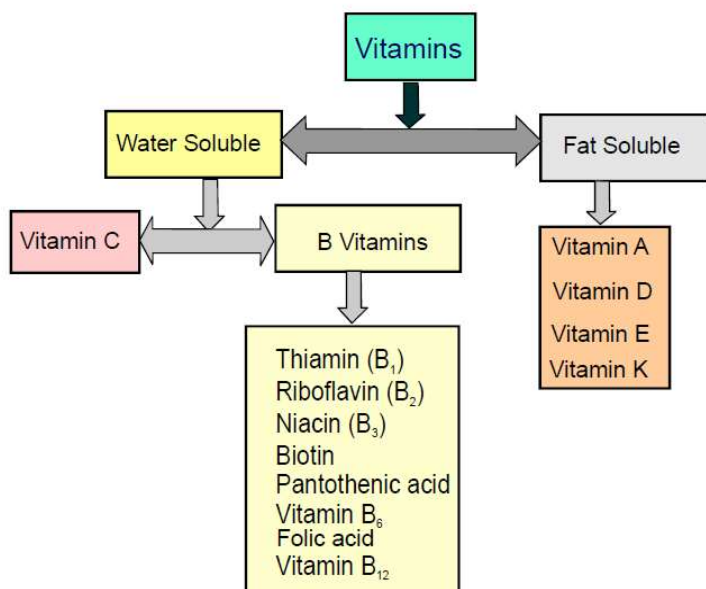


Fig. 2.1: Classification of vitamins.

2.3 VITAMIN: NUTRITIONAL DEFICIENCY DISEASES

2.3.1. Beriberi - Thiamin Deficiency Disease

Beriberi is primarily a thiamin-deficiency disease. Thiamin deficiency is caused by poor diet and sedentary life practice specially smoking and alcoholism.

Beriberi is a polyneuritis syndrome that primarily affects the lower limbs resulting in muscle weakness, pain, weight loss, and partial paralysis. Loss of appetite and gastrointestinal disturbances are two of the most serious symptoms of beriberi. Affected individuals have extreme weakness, become lean and thin, cardiac problems and oedema, and mental depression, memory loss, anxiety, and other symptoms.

Vitamin B1, also known as thiamin or thiamine (Fig. 2.2). Being a water-soluble vitamin, it does not store in the body, so it is necessary to consume thiamin rich food on a regular basis to maintain its normal level. Thiamin diphosphokinase, an enzyme found in blood, converts thiamin into its active form, thiamin pyrophosphate (TPP). TPP as coenzyme is essential for glucose metabolism, Krebs cycle, and the pentose phosphate pathway. It helps in ATP production in the body via metabolizing of food stuffs. Thiamine deficiency affects the cellular metabolism resulting in impaired energy production (ATP).

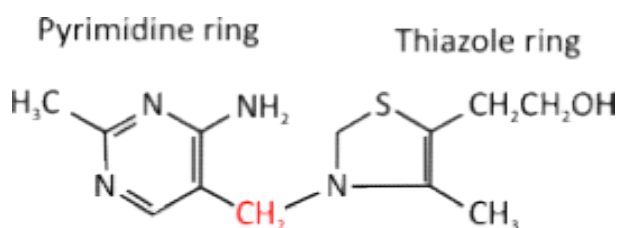


Fig. 2.2: Structure of thiamin.

Thiamin is found naturally in many dietary sources, is added to some foods, and is available in the form of dietary supplements. Thiamin is essential in the human body during energy metabolism.

Symptoms and consequences of Thiamin deficiency

Beriberi was the first vitamin deficiency disease to be discovered. Thiamin deficiency (vitamin B1) occurs when the recommended daily intake (RDI) is not met. However, deficiency can also occur due to impaired intestinal absorption or high excretion rates, such as in people suffering from alcoholism, acquired immunodeficiency syndrome (AIDS), or malnutrition.

Beriberi is a thiamin deficiency disorder which can cause three type of beriberi:

- 1) **Dry beriberi:** Dry beriberi mainly affects the function of nervous system. It exhibits symptoms like muscle weakness, seizures, or rapid tendon reflexes.
- 2) **Wet beriberi:** Wet beriberi affects heart and circulatory functions resulting in confusion, muscle atrophy, and edema.
- 3) **Infantile beriberi:** It occurs mainly in infants. The cardiovascular system of the infant is generally affected. Infants have edema, an unappealing appearance, anorexia, vomiting, and diarrhea in thiamin deficiency.

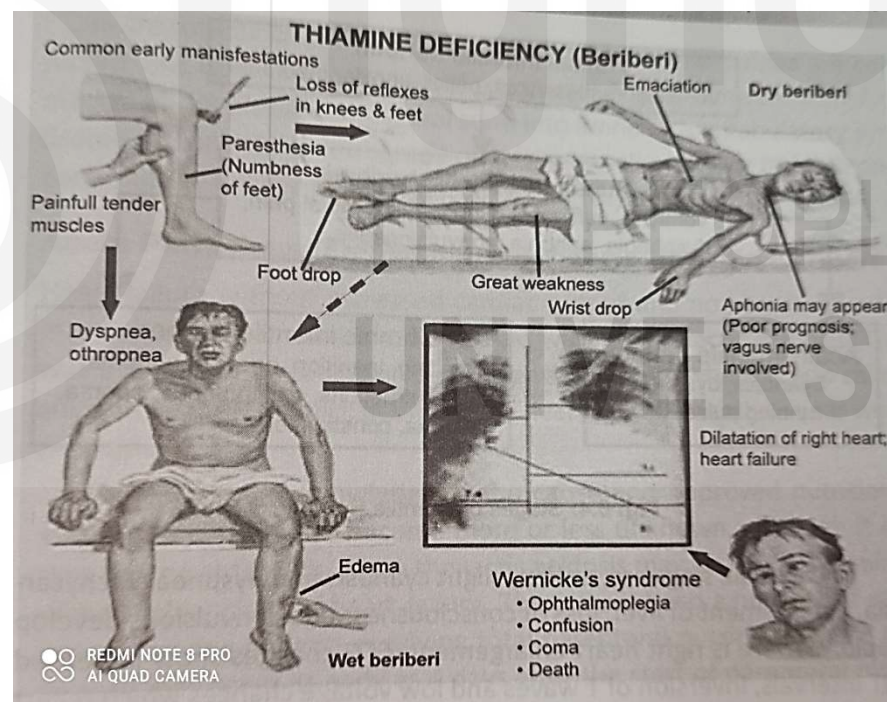


Fig. 2.3: Thiamin deficiency – Beriberi.

Genetic beriberi is a rare inherited condition (passed down through families) in which people have a decreased ability to absorb thiamine from food. This can happen gradually over time, and symptoms usually appear in adult stage.

TPP levels of < 70 nmol/L in human blood are generally indicative of thiamine deficiency. The most common symptoms are muscular weakness, loss of sensation, vomiting, nausea and confusion. It primarily affects the nervous and cardiovascular systems. Juvenile beriberi is rare and frequently misdiagnosed due to overlapping symptoms.

Dietary sources and RDA:

Cereals, groundnuts, soybean and capsicum are these good natural sources for thiamin. Recommended dietary for thiamine is 1.4 mg/day for male and 1.1 mg/day for female.

2.3.2 Pellagra - A Niacin Deficiency Disease

Niacin, also known as vitamin B₃, is a water-soluble vitamin that the body uses to create the nicotinamide coenzyme, NAD⁺. The term 'nicotinic acid' is frequently used to refer to niacin. Pellagra (pellis – skin; agra – rough) is a condition caused by a dietary niacin (vitamin B₃) deficit, mainly affecting people who eat a poor diet (low of niacin or tryptophan). While primary Pellagra is caused by a diet deficient in niacin and tryptophan, secondary pellagra is caused by an inability to use niacin in the diet. Niacin is important for macronutrient metabolism (carbohydrate, protein, and fat) because it is a component of the NAD and NADP coenzymes. Its deficiency inhibits the body's energy-yielding process by interfering with regular food metabolism. Niacin deficiency can occur as a result of genetic disorders, Alcoholism, Hartnup disease, malabsorptive conditions, or medication interactions.

Hartnup disease is a hereditary genetic disorder in which the small intestine and renal tubules fail to absorb tryptophan, resulting in tryptophan loss in the urine.

Symptoms and Consequences of Niacin deficiency

Pellagra symptoms might appear 6-8 weeks following a prolonged dietary shortage in niacin or tryptophan. Dermatitis, dementia, and indigestion are all symptoms of the disease, which is characterised by acute irritation and inflammation of the mouth's mucous membranes and other regions of the GIT. Pellagra symptoms are known as the **"three Ds"**: sun-sensitive dermatitis, diarrhoea, and dementia. Weakness, headaches, anorexia, numbness, skin lesions, and digestive issues are the first signs. The skin, forearms, chest, neck, and face might all show signs of the disease. Pellagra can cause health problems in children, such as a lack of appetite, indigestion, vomiting, constipation, and lethargy.



Fig. 2.4: Pellagra symptoms of dermatitis on hands.

Dietary sources: Peanuts, legumes, meat, eggs and milk are good sources of this vitamin.

The recommended daily allowance (RDA): About 16 mg per day for men and up to 14 mg per day for women. Children may require a well-balanced diet high in niacin-rich foods.

Niacin is used as a dietary supplement to treat pellagra. Pellagra can be treated by incorporating roughly 10 mg/kg of dietary tryptophan into the diet.

2.3.3 Vitamin B₁₂- Pernicious Anemia

Vitamin B₁₂ is the only vitamin that has cobalt metal ion as an essential component of its structure (Fig. 2.5). Hence, it is known as cobalamin. It is found in animal products like red meat, dairy, and eggs. Vitamin B₁₂ absorption requires the Intrinsic factor which is a glycoprotein produced by parietal cells in the stomach. Vitamin B₁₂ acts as a cofactor for enzymes involved in the synthesis of deoxyribonucleic acid (DNA), fatty acids, and myelin.

Human body cannot absorb vitamin B₁₂ due to malabsorption, or a lack of intrinsic factor. Vitamin B₁₂ deficiency is often caused by intestinal malabsorption rather than insufficient dietary intake. Unlike other vitamins, vitamin B₁₂ is stored in substantial amount mainly in the liver, which reduces the likelihood of deficiency. Vegans who do not take supplements or who have an absorption disorder are at risk of vitamin B₁₂ deficiency.

Plants do not produce vitamin B₁₂. Gut bacteria are the only ones which can produce vitamin B₁₂. Vitamin B₁₂ produced by bacteria is transformed into methylcobalamin and 5'-deoxyadenosylcobalamin in the human body.

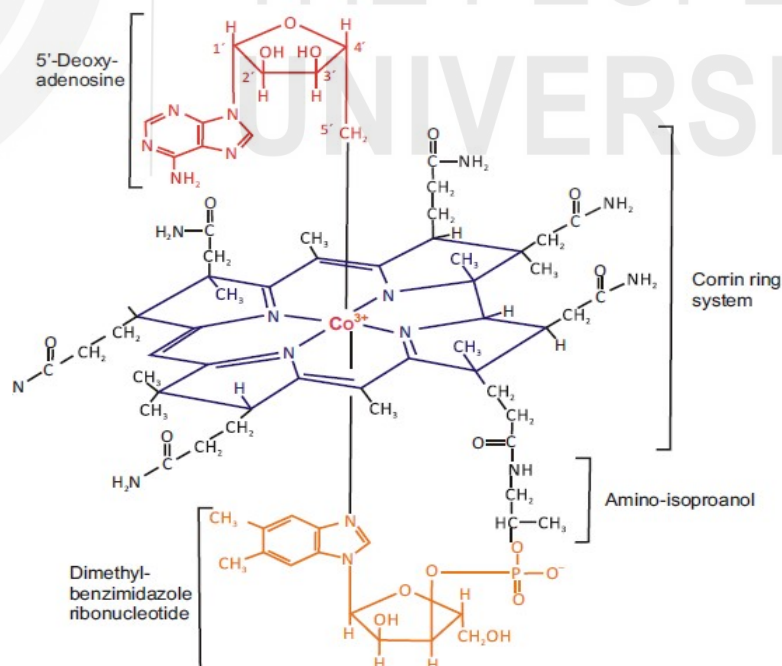


Fig. 2.5: Structure of Vitamin B₁₂.

(Sources: Principle of Biochemistry, Lehninger and COX)

Biochemical role of Vitamin B₁₂

Fig. 2.6 showed that vitamin B₁₂ as a cofactor functions in two ways in human metabolism. In the first reaction, vitamin B₁₂ breakdowns methylmalonic acid to succinyl-CoA and in the second reaction, it breakdown homocysteine to methionine amino acid in the presence of folic acid. In the absence of vitamin B₁₂, the catabolic reaction of methylmalonyl -CoA and homocysteine will stop and consequently, the level of these substances will be increased in tissue and serum. High level of homocysteine is called hyper homocysteinemia which indicates either vitamin B₁₂ deficiency or folic acid deficiency. Therefore, the measurement of methylmalonyl and homocysteine levels in serum is directly related to identify vitamin B₁₂ deficiency.

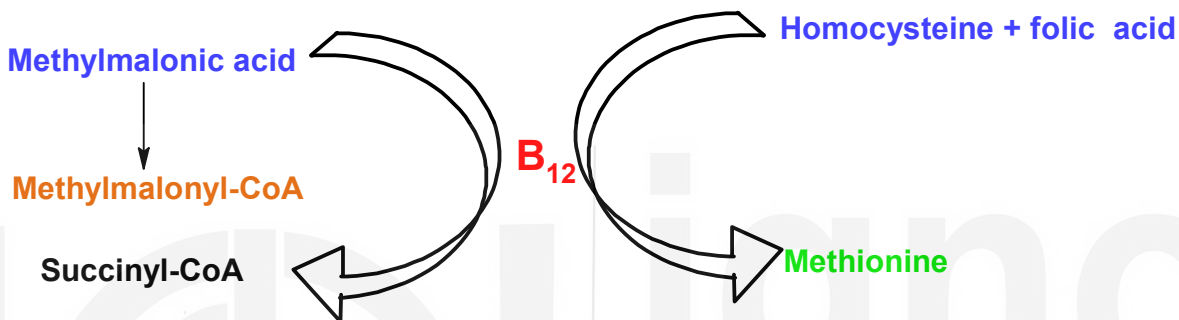


Fig. 2.6: B₁₂ mediated catabolic reaction of methylmalonic acid and homocysteine.

Vitamin B₁₂ deficiency

The scientist Combe described a kind of anemia as a digestive problem in patients who were unable to retain RBC in the blood in 1822, and Addison identified it as pernicious anaemia in 1849. **Pernicious anaemia** is mainly caused by stomach cells that are unable to produce intrinsic factor (IF). Human body cannot absorb vitamin B₁₂ in the absence of intrinsic factor. Low haemoglobin levels, a decreased number of erythrocytes, and neurologic manifestations are the symptoms of pernicious anemia.

Vitamin B₁₂ deficiency causes red blood cell enlargement with low haemoglobin content (macrocytic anemia). Vitamin B₁₂ deficiency generally occur those people who strictly are vegetarian. Deficiency of dietary vitamin B₁₂ or absence of intrinsic factor causes the symptoms of pernicious anaemia. The elderly is more prone to vitamin B₁₂ deficiency. A lack of vitamin B₁₂ can lead to degeneration of the spinal cord, optic nerves, cerebral tissue, and peripheral nerves. Its deficiency also causes abnormal level of homocysteine which can lead to develop dementia, blood clot, cardiovascular diseases and stroke.

Juvenile pernicious anaemia is a type of Vitamin B₁₂ deficient anaemia that affects newborns. It is a hereditary condition in which the IF gene in gastric cells fail to synthesize normal intrinsic factor, without which the body is unable to metabolize B₁₂.

Vitamin B12 deficiency can cause various health problems of hematological and neurological disorders. **Megaloblastic anaemia** develops in vitamin B12 deficiency or folic acid deficiency as a result of disrupted DNA synthesis, and a resultant blood cells maturation disorder, wherein nuclei are enlarged (Fig. 2.7). The oval shaped megaloblasts are degraded in the bone marrow, but few of them mature and reach the peripheral circulation with reduced functions. Thus, megaloblastic anaemia is marked by abnormally large red blood cells and a reduction in their number. This type of anemia can also be caused by a lack of folate (vitamin B9). These two vitamins work together to metabolize amino acids required for the production of healthy red blood cells. Vitamin B12 deficiency also affects amino acid metabolism.



Fig. 2.7: Megaloblastic anemia as a result of vitamin B₁₂ and folic acid deficiency.

Cobalamin deficiency also reduces the cell division and damages the myelin sheath in nerve tissues. Severe deficiency of vitamin B12 may lead to liver and kidney diseases. Its deficiency causes low level of tetrahydrofolate which is required for DNA synthesis. Therefore, B12 are essential for normal functioning of nervous system and production of healthy blood cells.

Fatigue is the most common symptom of vitamin B12 deficiency. The common sign and symptoms include:

- Weakness
- Breathing problems
- Dizziness
- Headache
- Hands and feet that are cold,
- Skin that is pale or yellowish in colour.
- Pain in the chest
- numbness and tingling in the hands and feet

- Appetite loss and weight loss
- Confusion and depression
- Poor memory

The level of serum cobalamin, as well as the serum methylmalonate and homocysteine is used to diagnose vitamin B12 deficiency.

RDA: Adults, 3 µg/day and upto 0.5-1.5 µg/day for children.

Dietary sources: The usual dietary sources are animal products such as meat, egg, fish and the probiotics.

2.3.4 Vitamin C Deficiency - Scurvy

You know that vitamin C is a water-soluble antioxidant vitamin. It is oldest vitamin and chemically known as ascorbic acid. It is also called antiscorbutic vitamin as it cures the scurvy diseases. It was isolated by king from the lemon juice. It is a ketolactone (C₆H₈O₆) contain six carbon atoms with hydroxyl groups that resemble glucose to some extent (Fig. 2.8). It is acidic in nature owing to ionization of two hydroxyl groups separated by the double bonds. It is quite optically active compound and a strong reducing agent. Vitamin C is a heat sensitive as it is easily breakdown at high temperature. It is stable in acidic medium but degrades in alkaline solution.

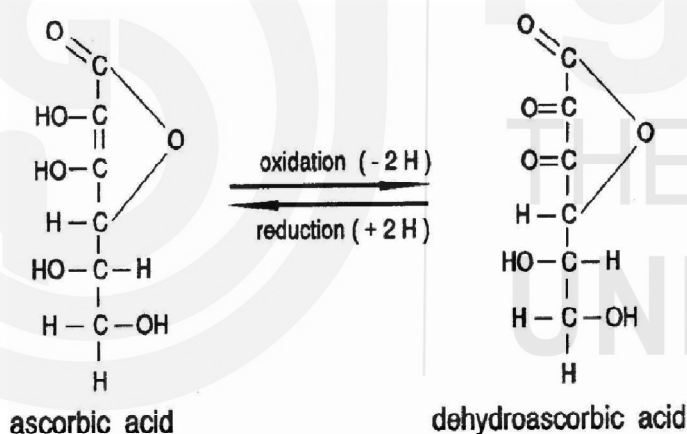


Fig. 2.8: Structure of ascorbic acid.

Vegetables and fruits account for up to 90% of vitamin C consumption as plants (fruits) synthesize this vitamin. Human cannot make vitamin C due to the lack of the enzyme L-gulonolactone oxidase and therefore, must include vitamin C rich food in the diet. It is easily absorbed via the active transport in the gastrointestinal tract and distributed in the body compartments via blood stream. However, it is often excreted through urine as it is not stored in the body.

The prominent role of vitamin C is the hydroxylation of proline and lysine residues required for the synthesis of collagen (Fig. 2.9). In hydroxylation, ferric iron (Fe³⁺) is reduced to ferrous iron (Fe²⁺) by ascorbic acid. Hydroxyproline stabilize triple helical structure of collagen. In absence of vitamin C, collagen fibers become weak and fail to form healthy scar tissues and further leads to weak bone structure (Fig. 2.10).



Dietary source of Vitamin C

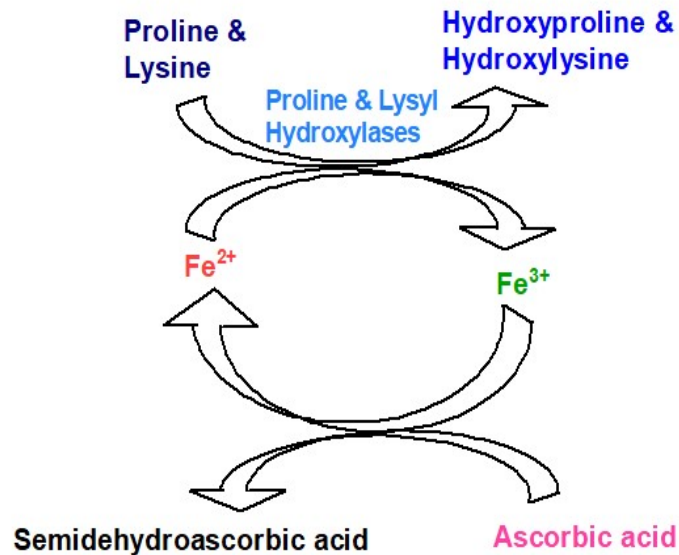


Fig. 2.9 : Ascorbic acid reduces iron so that it can continue to serve as a cofactor for proline and lysyl hydroxylases.

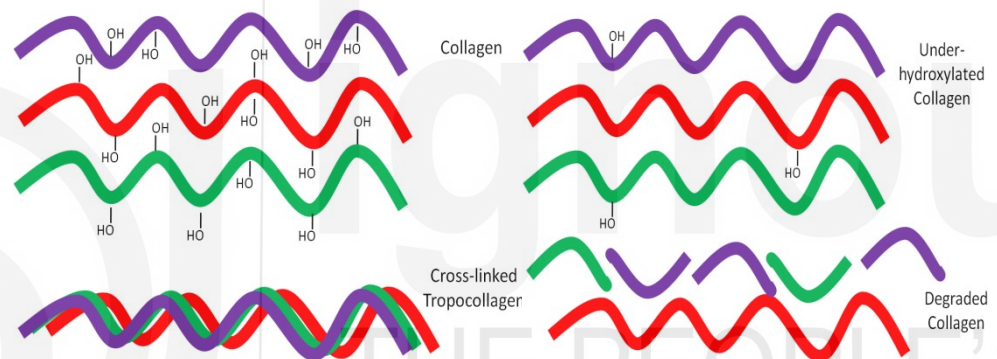


Fig. 2.10: (a) Hydroxylation stabilize collagen structure (b) unhydroxylated collagen destabilize collagen due to vitamin C deficiency.

Image source <http://goo.gl/vOAnR> under attribution CC BY 4.0

Deficiency symptoms and consequences of scurvy

Vitamin C deficiency can be caused by not eating enough fresh fruits and vegetables. A serum concentration of less than $11.4 \mu\text{mol/L}$ indicates vitamin C deficiency. Scurvy is characterized by blood capillary fragility and bleeding from the gums and teeth. It is a severe deficiency disease due to lack of vitamin C. It causes bruising, gum and dental issues (Fig. 2.11), dry hair and skin, and anaemia. However, scurvy in infants is uncommon because breast milk contains adequate amounts of vitamin C. It can be fatal, if vitamin C deficiency not treated in time.



Fig. 2.11: Symptoms of scurvy in teeth gum.

Scurvy symptoms appear after a few months of deficiency. The signs and symptoms of vitamin C deficiency are as follows:

- People are exhausted, weak, and irritable.
- Dry and splitting hair
- Easy bruising
- Gingivitis (gum inflammation)
- Nosebleeds
- Anemia
- Bleeding gums
- Decreased ability to fight infection
- Decreased wound-healing rate
- Weight gain due to slowed metabolism
- Rough, dry, scaly skin
- Swollen, painful joints
- Weakened tooth enamel

RDA: The recommended intake is 90 mg/day for male and 75 mg/day for female.

Dietary sources: The rich sources of vitamin C are citrus fruits and most green vegetables such as spinach.

SAQ 1

Fill in the blanks:

- The absence of thiamin causes.....diseases.
- Three Ds refers to
- The red blood cell enlargement with low hemoglobin content appear in.....
- Intrinsic factor is essential for absorption of.....
- Vitamin C deficiency causes
- Due to a lack of....., there is no hydroxylation of proline and lysine residues in collagen synthesis.
- Blood capillary fragility and bleeding from the gums and teeth are characteristic symptoms of.....

2.4 NUTRIENT DEFICIENCY - MALNUTRITION

Malnutrition occurs when an individual receives insufficient or excessive nutrients, resulting in health problems. It is specifically defined as "a deficiency, excess, or imbalance of energy, protein, and other nutrients" that has a negative impact on the human health. Malnutrition is the biggest health issue in Indian children. About one-third of the world's malnourished children live in India. Socio-economic disparity is a key factor of malnutrition in India. Because of the poor economic condition of various segments of the population, their nutrition frequently falls short in both quality and quantity. Malnourished women are less likely to produce healthy infants. Nutritional deficits have long-term harmful consequences for both people and society. Individuals who are malnourished are more susceptible to get infectious illnesses such as pneumonia and TB, which result in a higher death rate.

Malnutrition, as well as other undesirable physical or disease conditions linked with poor diet. Person that has lack of sufficient energy, protein, and micronutrients (vitamin and minerals) can be considered as an undernutrition. Essential dietary component with recommended dietary allowance is required for growth and development of child. Deficiencies in dietary energy and protein are common, and they are frequently linked to mineral and vitamin deficiencies.

Malnutrition occurs into two major forms of Protein Energy Malnutrition (PEM):
1. Marasmus, is nutritional disorder of a deficiency in energy-giving foods, and
2. Kwashiorkor is protein deficiency nutritional disorders. PEM is an abbreviation for protein-energy (or protein-calorie) malnutrition and is used to describe malnutrition. It refers to a variety of clinical disorders caused by various combinations and degrees of protein and energy deficiency (Fig.2.12).

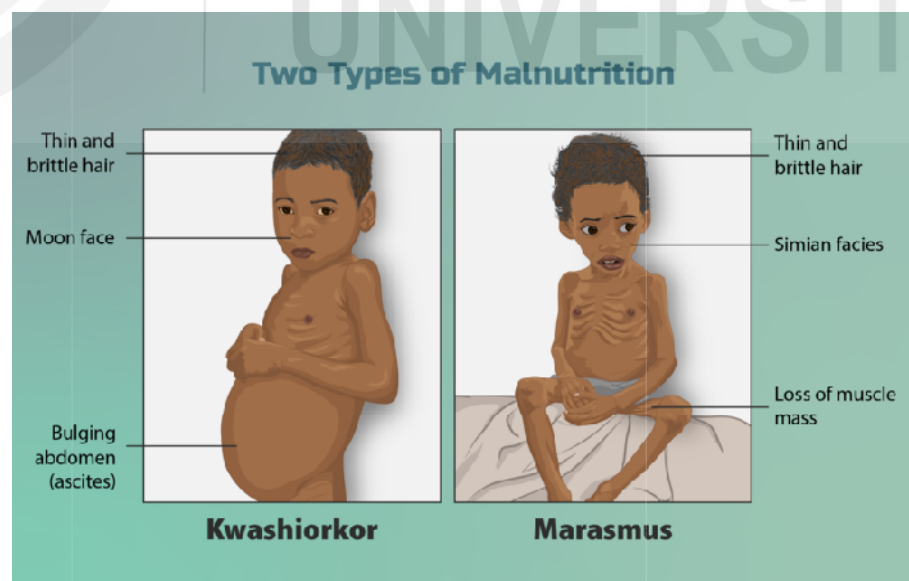


Fig. 2.12: Symptoms and physical morphology of child affected with kwashiorkor and marasmus. Image source : https://commons.wikimedia.org/wiki/File:Depiction_of_children_suffering_from_two_types_of_malnutrition.png

2.4.1 Kwashiorkor

Kwashiorkor is a severe type of malnutrition caused by the protein deficiency in the diet. It primarily affects children under the age of five, who do not consume enough proteins or other essential nutrients. Therefore, it is considered as protein deficiency disorder. The child is malnourished due to lacking of dietary protein. The primary cause of kwashiorkor is insufficient protein diet and other essential micronutrients (vitamins and minerals). It is most common in developing countries with a limited food supply, poor hygiene, and a lack of education. Although kwashiorkor can affect people of all ages, children are more likely to be more affected than adults.

Kwashiorkor malnutrition can also occur quickly as a result of an imbalance between consumption and nutritional requirements (RDA). It is distinguished by edema and an enlargement of the liver with fatty infiltration. In kwashiorkor, liver is large and fatty, with a significant decrease in plasma protein concentrations, particularly albumin. However, the precise cause of kwashiorkor is unknown.

Symptoms of kwashiorkor

The main symptom of kwashiorkor is the deposition of excess fluid in tissues, which causes swelling beneath the skin (oedema). It usually starts in the legs, but it can spread to the rest of the body, including the face. Other symptoms of kwashiorkor include:

- loss of muscle mass
- an enlarged tummy ("pot belly")
- regular infections, or more serious or long-lasting infections
- red, inflamed patches of skin that darken and peel or split open
- dry, brittle hair that falls out easily and may lose its colour
- failure to grow in height
- tiredness or irritability
- ridged or cracked nails

Diagnosis and prevention: Kwashiorkor, if left untreated for too long, can be fatal because children become extremely susceptible to infections.

Kwashiorkor is frequently diagnosed based on a child's physical appearance as well as diet and care questions.

However, a blood test and a urine test may be performed to rule out other conditions.

This can include tests to:

- measure blood sugar and protein levels; and
- check the function of the liver and kidneys by testing urine and blood for anaemia.
- determine the vitamin and mineral levels in the body.

Protein rich sources such as pulses, green vegetables, animal products (milk, Egg) nuts and cereals are recommended for curing the Kwashiorkor.

2.4.2 Marasmus

Marasmus is another type of malnutrition characterised by a lack of energy. It is similar to starvation. It often occurs when the diet is severely deficient in calories (energy). Hence, it is energy deficiency disorder. It can affect young children in areas of the world where food supplies are unstable (developing countries). Deficiency of energy-giving foods predominates over protein deficiency. Unlike kwashiorkor; marasmus is linked to a response to insufficient energy intake. It can be treated with adequate energy rich nutrients/food.

Symptom and treatment:

Thinness and loss of fat and muscle without any tissue swelling are symptoms of marasmus. Children with marasmus have significant weight loss as well as a loss of subcutaneous fat and muscle mass. Ribs, joints, and facial bones protrude, and the skin is thin, loose, and wrinkled.

It significantly contributes to high rates of morbidity and mortality in children. It is now recognised as a public health issue, with government nutrition policies and health personnel responsible for reducing its scope.

All bodily processes, such as heart rate, kidney function, $\text{Na}^+ - \text{K}^+$ pump activity, and the inability to self-regulate body temperature, exhibit an adaptive reduction that conserves energy. Because of lower heart rates and circulating blood volumes, these children have a general decrease in cardiac activity. Marasmus is treated in the same way that kwashiorkor is.

SAQ 2

Differentiate between marasmus and kwashiorkor.

2.5 SUMMARY

- Vitamins are important dietary components for our health and life. Their inadequate amount in the human body cause serious health problems and diseases. Our body does not synthesize vitamins so we must include them as a part of the diet to fulfill RDA. However, vitamin rich foods are green vegetables, nuts, seeds, legumes, meats, milk, liver, fish and egg.
- B complex vitamins primarily serve as coenzymes for metabolic enzymes which assist in transferring of functional groups during biochemical reaction. They also help in breakdown of food stuffs.
- The term "dry beriberi" refers to the presence of polyneuropathy, whereas "wet beriberi" refers to the development of high-output cardiac failure and peripheral edema.

- Niacin is a precursor to the coenzymes NAD and NADP, both of which act as hydrogen transfer agents in biochemical reactions. Pellagra is caused by a niacin deficiency. Niacin deficiency is caused by a diet deficient in tryptophan or niacin. The rough skin and dermatitis are the primary symptoms of pellagra. Pellagra is characterised by 3Ds i.e. dermatitis, dementia, and diarrhea. People with alcohol drinking and liver diseases are prone to develop niacin deficiency.
- Vitamin B12 is the only vitamin that contains a cobalt metal ion. Its deficiency or absorption defect in vitamin B12 causes pernicious anaemia. Fatigues, nausea, weakness, constipation, nerve issues such as numbness or tingling, are primary symptoms of vitamin B12 deficiency. Animal products are the primary source of this vitamin. Folic acid (active form: tetrahydrofolate) and vitamin B12 work together to promote the development of red blood cells in humans.
- Vitamin C is a natural anti-oxidant molecule that is required for keeping healthy body. The molecule gluconolactone acts as "cement" in holding cells and tissues together. It is required for collagen synthesis, wound healing, and immune system function. Its deficiency leads to develop scurvy. The bleeding gum is the common symptoms of scurvy. Citrus fruits and green vegetables are rich sources of vitamin C.
- The two most common types of malnutrition are marasmus (caloric malnutrition) and kwashiorkor-like (protein malnutrition).
- Marasmus is a severe nutritional malnutrition caused by a lack of calorie rich food in diet. It is characterised by losing of body tissues, particularly muscles and subcutaneous fat.
- Patients affected with marasmus do not consume enough energy rich foods in general while kwashiorkor's patients do not consume enough protein rich diet.

2.6 TERMINAL QUESTIONS

1. Explain cause and biochemical effect of thiamin deficiency.
2. Explain causes, symptoms and metabolic effect of vitamin B₁₂ deficiency.
3. Identify locally available foods that are good sources of niacin and thiamin vitamin.
4. Write the biochemical symptoms of pernicious anemia and megaloblastic anemia.
5. Explain the malnutrition and their common type with symptoms.
6. Draw the well-labeled diagram of cobalamin.

2.7 ANSWERS

Self Assessment Questions

1.
 - i) Beriberi disease
 - ii) Dermatitis, diarrhea, and dementia
 - iii) Pernicious anemia
 - iv) Vitamin B12
 - v) Scurvy
 - vi) Vitamin C
 - vii) Scurvy

2.	Kwashiorkor	Marasmus
	occurs due to intake of insufficient protein in the diet	Energy deficiency malnutrition due to insufficient intake of energy rich nutrients (carbohydrates, protein, and fat etc.).
	Child shows edema (swelling), anemia with enlargement of the liver (large belly)	loss of body's weight (wasting of muscles).
	Occurs upto 1-5 years old children.	Occurs upto 1-2 year old infants.

Terminal Question

1. Please refer to section 2.2.1
2. Please refer to section 2.2.3
3. Please refer to section 2.2.2 & 2.2.3
4. Please refer to section 2.2.4
5. Please refer to section 2.2.4
6. Please refer to section 2.2.3