UNIT 6 THE MICRONUTRIENTS–I : VITAMINS

Structure

6.1 INTRODUCTION

You learnt about the sources, functions and utilization of macronutrients in Units 4 and 5. We will now begin our discussion on micronutrients with the study of vitamins in this Unit.

The "vita" part of the word "vitamin" means "life". Vitamins (like carbohydrates, fats and proteins) are organic compounds. Unlike these nutrients, however, vitamins are present in minute quantities in food. This does not mean we need vitamin pills to meet our needs! We can meet our requirements for vitamins quite easily by consuming the right types of foods.

Some of the vitamins are soluble in water while others are soluble in fat. They are hence classified into two categories: water-soluble vitamins and fat-soluble vitamins. This unit will introduce you to the different vitamins included in each of these categories. You will learn about the food sources and functions of these vitamins.

Objectives

After studying this Unit, you will be able to:

- differentiate between fat-soluble and water-soluble vitamins
- identify the food sources of each vitamin
- state the important functions of each vitamin in the body

6.2 FAT-SOLUBLE VITAMINS

Vitamins A, D, E and K are known as the fat-soluble vitamins. These vitamins are, therefore, present in food dissolved in the fat they contain. An interesting fact about fat-soluble vitamins is that after being used for specific functions, the excess amount of these vitamins is stored in the body. You have learnt about the importance of bile in the digestion of fats in Unit 4. This means that fat-soluble vitamins would remain dissolved in the fats and would be absorbed only after the fats are digested.

6.2.1 Vitamin A

Vitamin A or *retinol* is found only in the foods of animal origin. Animal foods like milk, butter, ghee, egg, fish and liver are rich sources of vitamin A. Liver oils of fish like halibut, cod, and shark are the richest sources.

Plant foods do not contain retinol. They contain certain orange or yellow coloured pigments called carotenoids which can be converted to retinol in the body. In other

words these carotenoid pigments are precursors of vitamin A. The word "precursor", refers here to a substance which can be converted to the vitamin in the body.

Beta carotene is the most widely distributed carotenoid in plant foods. Most of the yellow and orange colour of vegetables and fruits is due to these carotenoid pigments as we mentioned earlier. Ripe fruits such as mango, papaya and yellow/orange vegetables like carrot and pumpkin are rich in beta carotene. Green leafy vegetables also contain carotenoid pigments. Here the yellow and the orange colour of the carotenoid pigments is marked due to the presence of another pigment called chlorophyll which, as you may know, is green in colour. Green leafy vegetables such as spinach, mustard leaves and fenugreek leaves are very rich sources of beta carotene.

We earlier mentioned specific animal foods which are rich sources of vitamin A. However, you know that animal foods are expensive. Most Indians do not consume enough animal foods to meet the vitamin A needs of the body. Hence they depend on plant foods to meet their vitamin A needs. Plant foods, as you know, do not have retinol. They contain beta carotene instead. The conversion of beta carotene to vitamin A or retinol is not very efficient in the body. In fact only half of the beta carotene absorbed is converted to retinol. Thus people who consume less animal foods need to consume enough plant foods such as green leafy vegetables and orange-yellow fruits to meet vitamin A needs.

Functions: What does vitamin A do in the body? This remarkable substance has, in fact, three important functions as listed below:

1) **Maintaining normal vision:** Vitamin A plays an important role in maintaining normal vision. To understand this better, we must first be familiar with the structure of the eye. Look at Figure 6.1. Can you spot the retina?

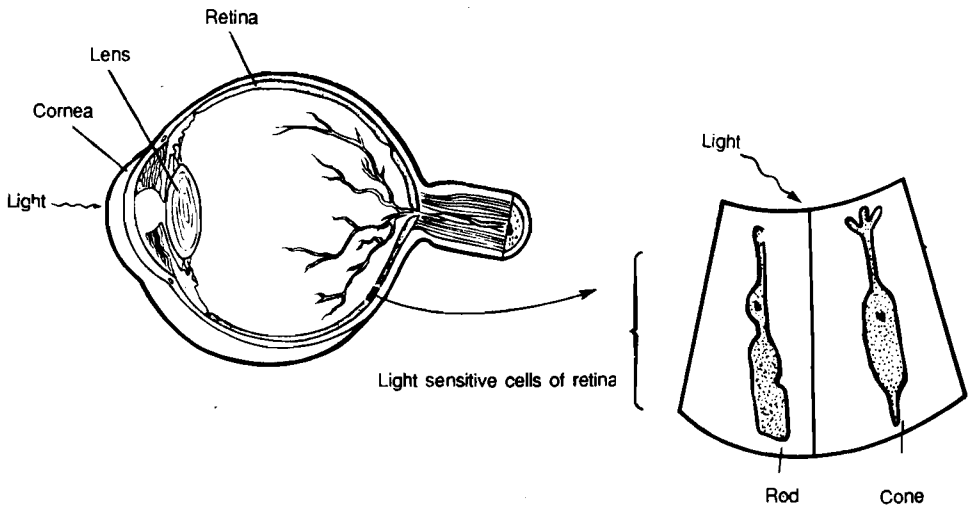

Fig. 6.1 : Structure of the eye

Adapted from illustration in Essentials of Nutrition and Diet Therapy by Sue R. Williams, Times Mirror, Mosby College Publishing, 1986 (4th edition)

The retina has two kinds of cells — rods and cones. Both rods and cones are sensitive to changes in light but they react differently and perform different functions. While rods are sensitive to dim light, the cones respond to bright light.

Let us take a closer look at the rods. The rods contain a pigment called rhodopsin. Rhodopsin is formed by the combination of a specific form of vitamin A with a protein. The amazing thing about rhodopsin is that it breaks down into its components when exposed to bright light. In the dark these components — vitamin A and protein — again combine to regenerate rhodopsin.

Now, what is the significance of rhodopsin in maintaining normal vision? Rhodopsin helps us to see in dim light. Consider the following situation. There must have been many occasions when you walked into the dark from a brightly lit room. You would definitely remember not being able to see for a short while. Why does this happen? It's all because the rhodopsin has broken down into its two components. It is, therefore, no longer able to perform its functions. How, then, did you begin to see in the dark? This happened because rhodopsin is regenerated once again in the dark. This visual cycle is depicted in Figure 6.2.

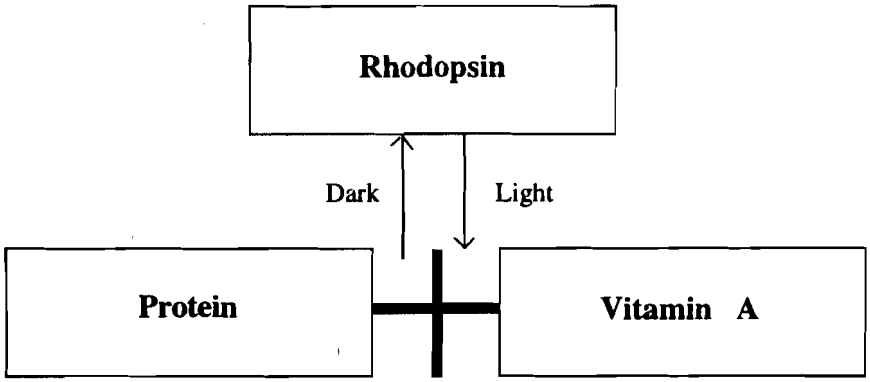

Fig. 6.2 : Simplified version of visual cycle

2) **Supporting growth:** Vitamin A is essential for the growth of the skeleton and soft tissues. The exact role of the vitamin in the growth of the body is still not understood. Research studies in this area have indicated that with the deficiency of vitamin A in the body, bones do not grow to their full length and the overall growth of the body is affected.

3) **Protecting against disease:** Vitamin A plays an important role in keeping epithelial tissues moist and healthy. Some examples of epithelial tissues are the skin, the lining of our eyes and the lining of organs like the intestine and lungs. Without vitamin A the epithelial tissue will become dry and cracks will appear in the skin or inner walls of the digestive tract or lungs. This makes it easy for the germs to enter and cause diseases like diarrhoea, respiratory infections and eye infections. Various research studies have supported this and shown that vitamin A plays a beneficial role in preventing common illnesses in young children. When body levels of vitamin A are low, the chances are more that the young child will develop infectious diseases. If these diseases are sufficiently severe they can even cause death.

6.2.2 Vitamin D

Vitamin D is also called the "sunshine vitamin". This is because it is manufactured from a substance present in our skin on exposure to sunlight. As a result of this, we do not necessarily have to depend on dietary sources of vitamin D. The easiest way of obtaining the vitamin is, in fact, enough exposure to sunlight.

Which foods contain vitamin D? Foods of animal origin like eggs, liver and butter contain the vitamin in significant amounts. It is, however, the fish liver oils which are the richest sources. On the other hand, most of the commonly used foods of plant origin do not contain vitamin D.

Functions: You might have heard that vitamin D makes bones strong and healthy. This is absolutely correct. How does vitamin D help in this? Read on to find out. Minerals like calcium and phosphorus, when deposited in the bones, make them strong and hard. The process of deposition of minerals in the bones is termed as mineralization of bones. Vitamin D *aids the process of mineralization* in two ways:

i) by increasing the absorption of calcium and phosphorus and

ii) by helping in the deposition of calcium and phosphorus in bones.

Check Your Progress Exercise 1

1) What are carotenoids? List the rich sources of beta carotene.

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2) Indicate whether the following statements are true or false. Correct the false statements.

a) Bile is essential for effective absorption of vitamin A and D. (True/False)

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b) We meet most of our vitamin D needs from dietary sources. (True/False)

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c) Vitamin A keeps the epithelial tissue dry. (True/False)

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d) Rods of the retina are sensitive to dim light (True/False)

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e) Vitamin D is also known as the "sunshine vitamin". (True/False)

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6.2.3 Vitamin E

Vitamin E is present in almost all foodstuffs. Vegetable oils like groundnut, soya, cottonseed and safflower are rich sources of vitamin E. Other good sources are whole grain cereals, dark green leafy vegetables, pulses, nuts and oilseeds. Foods of animal origin are low in vitamin E. However, foods like egg yolk, butter and liver contain some amount of the vitamin.

Functions: The main role of vitamin E in our body is the protection it gives to other substances like certain fatty acids, vitamins A and C. It prevents their destruction in the body as well as in foods.

6.2.4 Vitamin K

Among plant foods, green leafy vegetables like spinach, cabbage and lettuce are rich sources of vitamin K. Other good sources include animal foods such as egg yolk, milk and organ meats like liver. Vitamin K is also manufactured by certain helpful bacteria which are normally present in the small intestine. Approximately half of the vitamin K needed by us gets manufactured in the intestinal tract and the other half is obtained from animal and plant foods.

Functions: Have you ever observed what happens when you cut your finger? Your finger, of course, starts bleeding. But after a while blood stops oozing out. Why? This is because a clot is formed on the wound and seals it off. Vitamin K plays an important role in clotting of blood and is therefore also termed as the "antibleeding vitamin" (one which prevents uncontrolled bleeding). How does vitamin K help in clotting of blood? It helps in the formation of a protein called *prothrombin* which, in turn, is essential for blood clotting.

Check Your Progress Exercise 2

1) Match the following.

a)	Vitamin A	i)	Prevention of destruction of unsaturated fatty acids
b)	Vitamin D	ii)	Vision in dim light
c)	Vitamin E	iii)	Clotting of blood
d)	Vitamin K	iv)	Absorption of calcium and phosphorus

2) Fill in the blanks.

i) ..... are the richest sources of vitamins A and D.

ii) Rods of the retina are sensitive to .....

iii) Presence of ..... and ..... aids in the absorption of fat-soluble vitamins.

iv) Vitamin K is also known as the ..... vitamin.

6.3 WATER-SOLUBLE VITAMINS

We have so far studied the fat-soluble vitamins. Let us now move on to the water-soluble ones. Vitamin C and vitamins of the B-complex group are known as water-soluble vitamins owing to their solubility in water. Unlike the fat-soluble vitamins, these vitamins cannot be stored in our body in considerable amounts. The excess amount of these vitamins is instead excreted from the body in the urine.

6.3.1 Vitamins of the B-Complex Group

As the name indicates, this is a group of vitamins with similar functions. Vitamins of the B-complex group include: thiamine (B_1), riboflavin (B_2), folic acid, niacin and Vitamin B_{12}. They usually occur together in foods. The B vitamins help in the metabolism of carbohydrates, proteins and fats.

Let us now learn more about the food sources and functions of each of these vitamins.

Thiamine or B_1: Thiamine or B_1 is widely distributed in animal and plant foods. Almost all the foodstuffs except fats, oils and sugar contain small amounts of thiamine. Plant foods such as whole grain cereals (i.e. wheat and rice) and whole pulses are also rich sources of thiamine.

Among the foods of animal origin lean meats, poultry and egg yolk are good sources. One point that needs to be emphasized here is that the processing of cereals and pulses can significantly after their thiamine content as well as the content of some of the other vitamins. You will find more information on this aspect in Highlight 1. The discussion is relevant not just to thiamine but to other vitamins as well.

HIGHLIGHT 1	Influence of Processing on Nutritive Value

We use various methods to process our foodstuffs. Processing, in fact, includes all those procedures which foods are subjected to from the time of harvest to consumption. This means pre-preparation and preparation/cooking are also forms of processing. Here we will look at some specific examples of processing—processing of wheat, processing of rice and the pre-preparation procedures like sprouting and fermentation.

- **Processing of wheat:** Wheat is usually not consumed in the form of wheat grains as such but in the processed form e.g. whole wheat flour (atta), refined wheat flour (maida and suji/rawa). Most of the thiamine and other B vitamins

are present in the outer covering or bran and the germ layer of the wheat grain. Atta or whole wheat flour has most of the bran and part of the germ layer in it and is a good source of thiamine. However, maida and suji have very little bran and germ and hence are poor sources of thiamine and other B-complex vitamins in general.

- **Processing of rice:** Polished rice is very poor in B-complex vitamins — thiamine in particular. What do we mean by polishing? Paddy (or rice with husk) is either ground in machines or pounded by hands to remove the outer husk. After this the grain is further cleaned to give it a white, polished appearance. Removal of husk and polishing both cause heavy losses of thiamine as well as some of the other B vitamins.

  Rice is also available in another form called parboiled (sela) rice. Parboiled rice is prepared by soaking raw rice in water for 2 to 3 days, boiling or steaming and then drying. During this process most of the nutrients present in the outer layers of the grain move to its interior. Thus thiamine and the other vitamins are not lost when the outer layers of rice are removed during subsequent processing.

- **Sprouting and fermentation:** Sprouting and fermentation of whole grain cereals or pulses increases their content of B-complex vitamins and vitamin C. Sprouting, as you know, is the process of growing or germination of seeds or grains by first soaking them in water and then leaving the grains moist for about 24 hours by wrapping them in moist cloth (Figure 6.3). You can sprout whole pulses like green gram and use them for making raita (a curd preparation), stuffed paranthas or eat them as such in the form of salads.

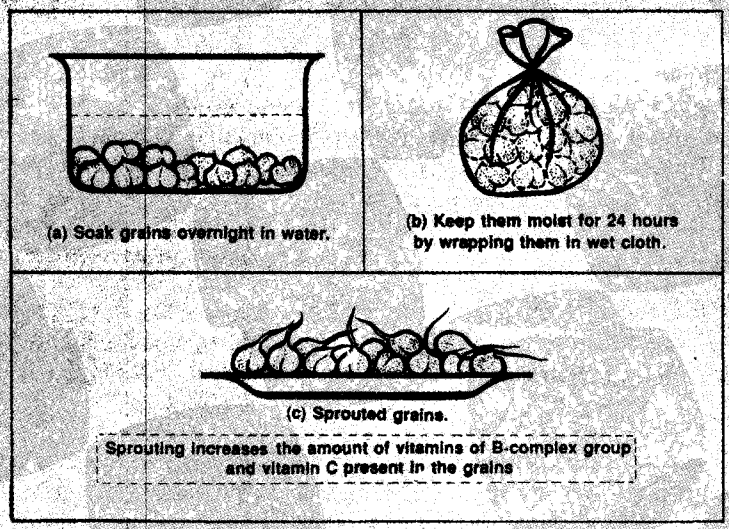

Fig. 6.3 : Sprouting of grains

Fermentation, on the other hand, refers to the chemical changes taking place in certain foods when mixed in a ground form with added fluid and kept overnight at a suitable temperature. During this time certain beneficial bacteria multiply and grow in the food mixture and bring about some desirable changes in it. You may already be familiar with these changes.

Fermentation makes the mixture light and fluffy in appearance and more digestible. Let us now talk about some fermented foods. Idlis are commonly consumed in the south and are made by steaming a fermented mixture of rice and urad dal. Similarly dhokla, a dish consumed in West India (Gujarat), is prepared by steaming a fermented mixture of curd and besan (bengal gram flour). After ingestion, thiamine is absorbed and enters the bloodstream. It is utilized to perform several important functions. Excess thiamine (i.e. the amount in excess of the body needs) is excreted in the urine.

You would now be interested in finding out what exactly thiamine does in the body. Thiamine plays an important *role in the metabolism of carbohydrates.* It helps the body cells to utilize glucose in order to release energy.

Riboflavin or B_2: Riboflavin or B_2 is widely distributed in plant and animal foods. Milk, liver, kidney, eggs and green leafy vegetables are good sources of riboflavin. Whole grain cereals and pulses contain fair amounts. On refining there is some loss of the vitamin. However, sprouting and fermentation of whole grain cereals and pulses can markedly increase their content of riboflavin and other B vitamins as mentioned in Highlight 1. An average mixed diet including milk, green leafy vegetables, whole cereals and pulses (especially when sprouted) can take care of the riboflavin needs of vegetarians. Non-vegetarians can also obtain riboflavin from animal foods.

How is riboflavin used by the body? Riboflavin plays an *important role in the metabolism of carbohydrates, fats and proteins.* This is because of the fact that it forms part of two distinct coenzymes which help to release energy from the end products of digestion of carbohydrates, fats and proteins.

Niacin: Niacin is another member of the B-complex family. The good sources of niacin include meat, fish, poultry, cereals, pulses, nuts and oilseeds. One interesting point about niacin is that it can also be formed in the body from a particular amino acid called tryptophan. Milk is a good example of a food rich in tryptophan but not in niacin. The tryptophan present in milk protein can be converted to niacin in the body. Thus milk provides appreciable amounts of niacin.

Niacin (like riboflavin) helps to *release energy from the end products of the digestion of carbohydrates, fats and proteins.* It thus helps in their metabolism.

Folic acid: Folic acid is also widely distributed in foods. Green leafy vegetables and organ meats (like liver and kidney) are very rich sources of folic acid. Whole grain cereals, pulses, eggs and dairy products are also good sources of folic acid.

After absorption folic acid is taken to various body tissues through the bloodstream for specific functions.

Folic acid plays an *important role in blood formation.* You may be aware that blood has three kinds of cells — red blood cells, white blood cells and platelets — suspended in a fluid called plasma. Specifically, folic acid is important for the proper development of red blood cells.

Vitamin B_{12} or Cobalamin: Vitamin B_{12} or cobalamin is present only in the foods of animal origin. Liver, kidney, milk, eggs and sea foods (e.g. shrimps, crabs, lobsters) are rich sources of vitamin B_{12}. Plant foods do not contain the vitamin. Vitamin B_{12} is also synthesized in our body in the intestinal tract by certain helpful bacteria.

Our body's requirement for vitamin B_{12} is very small. Consumption of even small amounts of animal foods like milk can take care of the vitamin B_{12} needs of the body.

Vitamin B_{12} is necessary for the *proper functioning of the digestive tract, nervous system and the bone marrow.* In the bone marrow, vitamin B_{12} (like folic acid) is also involved in the *formation of normal red blood cells.*

Check Your Progress Exercise 3

1) How do sprouting and fermentation change the content of B vitamins in the body?

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2) Which B vitamins play a significant role in blood formation?

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6.3.2 Vitamin C

Vitamin C or ascorbic acid is also termed as the "fresh food vitamin" because fresh fruits and vegetables are its major sources (Figure 6.4). Fresh citrus fruits (like orange, lime and lemon) and other fruits and vegetables like guava, amla, papaya, green leafy vegetables, tomatoes, green chillies and capsicum are some of the excellent sources of vitamin C. Root vegetables like potato and sweet potato contain small amounts of the vitamin and they contribute significant amounts only when consumed in large quantities. Cereals and pulses as such are poor in vitamin C but when sprouted and fermented become good sources. Animal foods like fish, meat, milk, poultry and eggs contain little or no ascorbic acid.

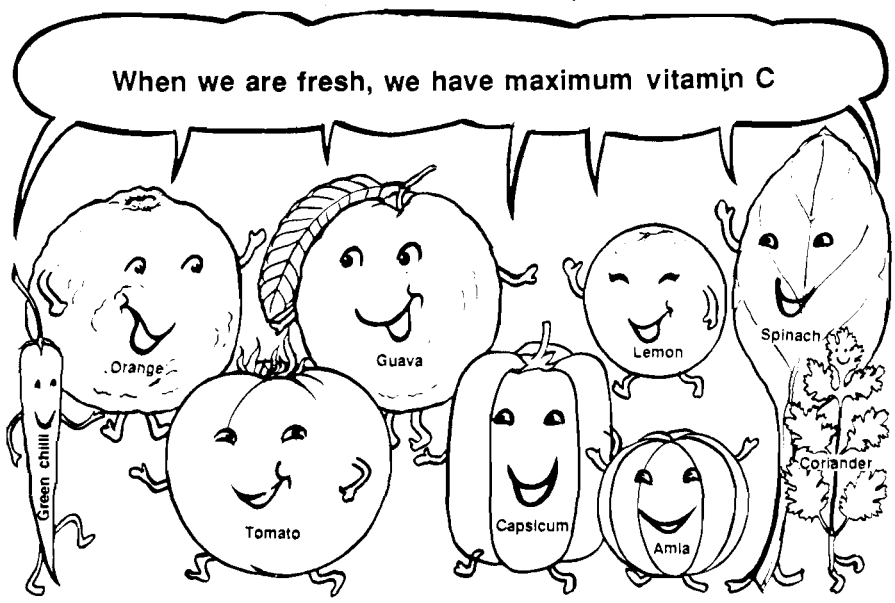

Fig. 6.4 : Vitamin C is a fresh food vitamin

Fruits like amla, guava, green leafy vegetables and green chillies are examples of some of the cheap sources of vitamin C. In fact, amla is the cheapest source and provides 20 times or more ascorbic acid as compared to the expensive citrus fruits.

Vitamin C plays a role in:

1) Healing of wounds and making blood vessels firm.
2) Overcoming conditions of injury, infection and other stresses.
3) Aiding absorption of iron.
4) Protecting certain substances from breakdown in the body e.g. vitamin A and some fatty acids.

Check Your Progress Exercise 4

1) Give reasons for the following:

   i) Refined flours like maida and suji have less thiamine as compared to atta or whole wheat flour.

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   ii) Milk can help to meet niacin needs.

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   iii) Ascorbic acid is termed the "fresh food vitamin".

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6.4 SUMMING UP

Vitamins are organic compounds (other than carbohydrates, fats and proteins) which are needed only in small amounts by the body. They are divided into two categories — fat-soluble vitamins and water-soluble vitamins. Important functions and food sources of fat-soluble and water-soluble vitamins are summarized in Tables 6.1 and 6.2 respectively.

Table 6.1 : Summary of Fat-soluble Vitamins

Vitamin	Sources	Functions
Vitamin A	• *Retinol* Liver, egg, yolk, cream, butter, ghee, milk	• Maintenance of health of epithelial tissues. • Vision in dim light.
	• *Beta Carotene*: Yellow and orange vegetables, green leafy vegetables	• Growth of skeletal and soft tissues
Vitamin D	• Action of sunlight on skin • Animal foods like eggs, butter, fish liver oil	• Calcium and phosphorus absorption • Deposition of calcium and phosphorus in bones
Vitamin E	• Vegetable oils, whole grains, deep green leafy vegetables, pulses, nuts and oilseeds	• Protection of unsaturated fatty acids, vitamins A and C from destruction in the body/food
Vitamin K	• Dark green leafy vegetables, egg yolk, liver • Bacterial synthesis	• Clotting of blood

Table 6.2 : Summary of Water-soluble Vitamins

Vitamin	Food Sources	Functions
Vitamins of the B-complex Group		
Thiamine or B_1	• Whole grain cereals, pulses, nuts, egg yolk, meat	• Role in carbohydrate metabolism in particular
Riboflavin or B_2	• Green leafy vegetables, milk, eggs, organ meats like liver, kidney	• Role in the metabolism of carbohydrates, fats and proteins
Niacin	• Cereals, pulses, milk, nuts and oilseeds, organ meats, fish	• Role in the metabolism of carbohydrates, fats and proteins
Folic acid	• Whole grain cereals, leafy vegetables, milk and eggs, organ meats like liver and kidney	• Role in the formation of normal red blood cells in the bone marrow
Vitamin B_{12}	• Animal foods like milk, eggs, organ meats	• Role in the formation of normal red blood cells in the bone marrow and proper functioning of the digestive tract and nervous system
Vitamin C	• Citrus fruits, amla, guava, capsicum, green leafy vegetables, green chillies	• Role in collagen formation and hence in wound healing. • Role in absorption of iron and prevention of destruction of other substances.

6.5 GLOSSARY

Beta carotene : A fat-soluble carotenoid pigment present in plants which is a precursor of vitamin A.

Chlorophyll : A pigment in plants which gives them their green colour.

Lean meat : Meat with low fat content

Processing : Refers to the treatment/preparation of foods/foodstuffs using specific techniques.

Refining : A processing procedure involving the removal of the outer covering of whole cereal or pulse grains.

Susceptible : Easily affected.

6.6 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) Carotenoids are yellow and orange coloured pigments present in plant foods. These carotenoids can be converted to vitamin A in the body and hence are termed precursors of vitamin A. Green leafy vegetables, yellow and orange vegetables like carrot and pumpkin and fruits like mango, papaya are rich sources of beta carotene.

2) a) True
   b) False; we meet most of our vitamin D needs from exposure to sunlight
   c) False; vitamin A keeps the epithelial tissues moist.
   d) True
   e) True.

Check Your Progress Exercise 2

1) a) ii);
   b) iv);
   c) i);
   d) iii)

2) i) Fish liver oils
   ii) dim light
   iii) fat, bile
   iv) antibleeding

Check Your Progress Exercise 3

1) Sprouting and fermentation increase the content of B-complex vitamins in foods

2) Folic acid and vitamin B_{12}.

Check Your Progress Exercise 4

i) Whole wheat flour has most of the bran and part of the germ layer in it and is a good source of thiamine. However, maida or refined flour has very little bran and germ. Since bran and germ are rich in thiamine and other B-complex vitamins, whole wheat flour is rich in thiamine while refined flour is poor in thiamine.

ii) Milk is a rich source of tryptophan. Tryptophan can be converted to niacin. This is why milk can help to meet niacin needs.

iii) Ascorbic acid is called the 'fresh food vitamin' because it is present in substantial quantities in fresh fruits and vegetables.