Vitamins

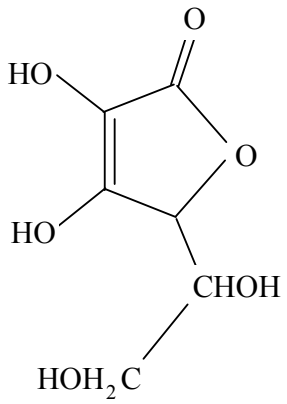
Introduction

Vitamins are minor or trace organic components of foods which maintain healthy life in living organisms. In general, they are needed in small amounts only – an excess of vitamin A, for example, can be toxic. Vitamins have a wide variety of structures and roles in maintaining human health. Vitamins can be divided into two major divisions, water-soluble vitamins and fat-soluble vitamins.

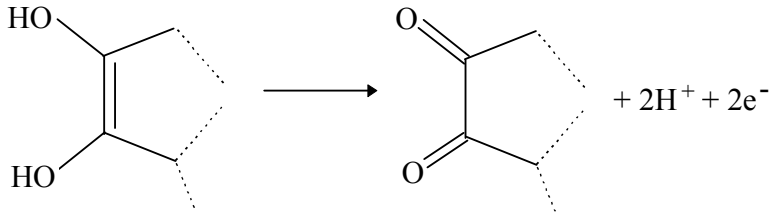
Water-soluble vitamins

Vitamin	B_1 (thiamin)	B_2 (riboflavin)	B_6 (pyridoxine)	B_{12} (cobalamin)	C (ascorbic acid)
Sources	most foods, including yeast, milk and meat				fruit and vegetables
Function	coenzymes				poorly understood
Deficiency symptoms	beriberi	mouth and tongue lesions	disruption of metabolism	pernicious anaemia	scurvy

These vitamins can be "leached" from food when it is cooked in boiling water. In vitamin C, there is an internal ester bond (**lactone**) which is hydrolysed under these conditions and causes it to lose its activity (vitamin B_1 is also unstable at such high temperatures). Vitamin C is also oxidised very easily:



Structure of ascorbic acid



Oxidation of ascorbic acid to dehydroascorbic acid

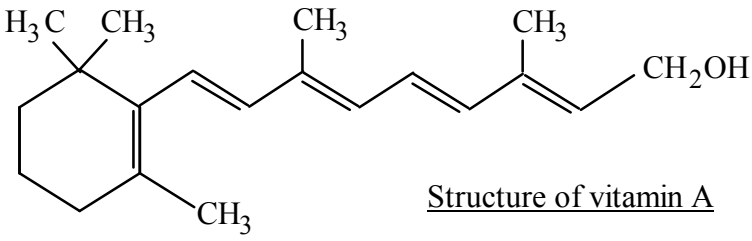
The ene-diol group behaves as a dibasic acid, but it easily oxidised to the diketo form (see above) known as dehydroascorbic acid. The most common oxidising agent for ascorbic acid is oxygen, and the product is very unstable. It is very difficult to control the oxidation of ascorbic acid because conventional antioxidants are ineffective – the only way to do it is to remove oxygen.

Fat-soluble vitamins

Vitamins that are soluble in fat but not in water include vitamins A and D (like the B vitamins, actually a mixture of compounds). Vitamin D, the "sunshine vitamin", is unusual in that it is the only one that the human body can synthesise for itself – all the others must be obtained from the diet.

Vitamin	A (retinol)	D
Sources	milk, cheese, margarine, liver paté, eggs, β-carotene from plants	cod-liver oil, eggs, milk, margarine; synthesised in response to sunlight
Deficiency symptoms	night blindness, dry skin and eyes	rickets

The structure of **vitamin A** (see right) has five conjugated C=C bonds (all *trans*) which give the molecule a yellow colour. A precursor of the vitamin is **β-carotene**, a long polyene with 11 conjugated C=C bonds. β-carotene has an orange colour and is found in plants such as carrots; vitamin A and related compounds are known as **carotenoids**.



Structure of vitamin A

Vitamin A tends to be associated with lipids in food, and its polyene structure means that it is sensitive to oxidation. This is particularly serious when fat oxidation is taking place, as free radical intermediates from unsaturated fatty acid residues can initiate the oxidation of these polyenes. In addition, absorption of light by polyenes causes *trans-cis* isomerism, leading to a change in the colour of β-carotene in foods (orange to pink), reducing the potency of vitamin A, and starting oxidation.

Vitamin Supplements

Some foods are "fortified" to ensure that a normal diet can provide sufficient vitamins to maintain health. For example, the milling of wheat removes the parts of the grain richest in vitamin B_1, so white flour has this vitamin added to it. Margarine has vitamins A and D added, and vitamin C is often added to fruit juices and dehydrated mashed potato.

Some vitamin-deficiency diseases

Beriberi (vitamin B_1 deficiency) is especially prevalent in those parts of the world where the diet consists mainly of polished rice. Symptoms include neuritis (e.g. tingling fingers and numb limbs), often with muscle wasting, poor co-ordination, and paralysis. Death may follow from heart failure.

Rickets (vitamin D deficiency) causes skeletal deformation, such as the curvature of the spine or legs.

The symptoms of **scurvy** include haemorrhages, loosening of teeth, and cellular changes in the long bones of children. The disease may appear in adults after about six months of complete lack of vitamin C, and it became prevalent when sailors began to spend months at sea without fresh vegetables (when it was usually fatal). In 1795, lime juice was issued to all British naval vessels on the recommendation of the Scottish doctor James Lind, and scurvy soon began to disappear among British seamen. As a result, Americans often regard the British as "limeys", although oranges and lemons actually have a higher vitamin C content than do limes.

Linus Pauling was an American chemist and physicist whose research included the discovery that sickle-cell anaemia is caused by a genetic defect in the production of haemoglobin. He advocated the use of massive doses of vitamin C to prevent illnesses including colds and flu. However, this has not been borne out by carefully controlled experiments. Unused vitamin C is quickly excreted in the urine, but large and prolonged doses can cause formation of kidney stones, destruction of vitamin B_{12}, and the loss of calcium from bones.