SECTION I

Fat-Soluble Vitamins

VITAMIN A (RETINOL)

Functions

Retinol performs the following functions in the body.

Vision

The chemical name *retinol* was given to vitamin A because of its major function in the retina of the eye. Retinol is an essential part of *rhodopsin*, which is a pigment in the eye commonly known as *visual purple*. This light-sensitive substance enables the eye to adjust to different amounts of available light. A mild deficiency of vitamin A may cause night blindness, slow adaptation to darkness, or glare blindness.

retinol (L. *retina*, from *rēte*, net, eye vision; suffix *-ol*, an alcohol) the chemical name of vitamin A; derived from its vision function relating to the retina of the eye, which is the back inner lining of the eyeball that "catches" the lens light refractions to form images interpreted by the optic nerve and brain and makes the necessary light-dark adaptations.

TABLE 7–1 Significant Food Sources of Vitamin A

Food item	Quantity	Vitamin A (μg RE)	Food item	Quantity	Vitamin A (μg RE)
BREAD, CEREAL, RICE, PASTA			***FRUITS (cont'd)***		
This food group is not an important source of vitamin A.			Banana	1 medium	69
VEGETABLES			Cantaloupe	¼ medium	1384
Asparagus	½ cup	196	Grapefruit, pink	½ medium	162
Beet greens	½ cup	1110	Orange juice	½ cup	73
Bok choy cabbage	½ cup	790	Papaya	1 cup, cubed	735
Broccoli, fresh	1 medium stalk	1350	Peach	1 medium	399
Broccoli, frozen	½ cup, chopped	721	Prunes, dried	4	207
Brussels sprouts	½ cup (4 sprouts)	121	Tangerine	1 medium	108
Carrots, raw	½ cup (1 medium)	2379	Watermelon	1 wedge (4 × 8 inches)	753
Collard greens	½ cup	2223			
Corn	1 small cob	93	**MEAT, POULTRY, FISH, DRY BEANS, EGGS, NUTS**		
Dandelion greens	½ cup	1843	Clams, canned	3 oz	144
Green beans	½ cup	102	Egg, whole	1 large	78
Green peas	½ cup	144	Beef liver	3.5 oz	10,831
Kale	½ cup	1369	Chicken liver	3.5 oz	4912
Lima beans	½ cup	60	**MILK, DAIRY PRODUCTS**		
Mustard greens	½ cup	1218	Cheddar cheese	1 oz	90
Pumpkin, canned	½ cup	2352	Milk, low-fat 2%, fortified	8 fl oz	150
Romaine lettuce	½ cup, chopped	157			
Spinach	½ cup	2187	Milk, skim, fortified	8 fl oz	150
Summer squash	½ cup	123	Milk, whole, unfortified	8 fl oz	101
Sweet potato, baked, in skin	1 medium	2769	Ricotta cheese, whole milk	½ cup	182
Tomato, cooked	½ cup	325			
Winter squash	½ cup	1021	Swiss cheese	1 oz	72
			Yogurt, whole	8 fl oz	84
FRUITS			**FATS, OILS, SUGAR**		
Apricot, dried	4 halves	490	Butter	1 Tbsp	138
Apricot, fresh	3 medium	867	Margarine	1 Tbsp	141
Avocado	1 medium	189			

RE = Retinol equivalent.

Tissue Strength and Immunity

Retinol maintains healthy *epithelial* tissue, which is the vital protective tissue covering the body (e.g., the skin) and the inner mucous membranes in the nose, throat, eyes, GI tract, and genitourinary tract. These tissues provide our primary barrier to infection. Vitamin A is also important in the production of immune cells responsible for fighting bacterial, parasitic, and viral attacks.

Growth

Retinol is essential to the growth of skeletal and soft tissues and influences the stability of cell membranes and protein synthesis.

Requirements

Retinol requirements are influenced by factors related to its two basic forms in food sources and its storage in the body. The established RDA standard for adults is 700 μg retinol equivalents (RE) for women and 900 μg RE for men.

Food Forms and Units of Measure

Retinol occurs in two forms, as follow: (1) retinol, the fully preformed vitamin A; and (2) **carotene**, the "provitamin A," which is a pigment in yellow and green plants that the body converts to vitamin A. Because vitamin A comes in these two food forms and most of our intake is usually from *beta-carotene*, which becomes retinol in the body, vitamin A is currently measured in *retinol equiva-*

lents. Another measure sometimes used for vitamin A is that of International Units (IU). One IU of vitamin A equals 0.3 μg retinol or 0.6 μg beta-carotene (see the For Further Focus box, "Small Measures for Small Needs").

Body Storage

The liver can store large amounts of retinol. In healthy individuals, the storage efficiency of retinol ingested in the liver is more than 50%, and the liver contains about 90% of the body's total store. Thus when persons take large supplements of retinol in addition to dietary sources, it is possible to take a potentially toxic quantity.

Deficiency Disease

Adequate intake of retinol prevents two eye conditions, as follow: (1) *xerosis*, which is itching and burning and red inflamed lids; and (2) *xerophthalmia*, which is blindness from severe deficiency. Dietary vitamin A deficiency is the number one cause of blindness in children worldwide.

As with all vitamins, deficiency symptoms are directly related to the functions of the vitamin. Therefore a lack of vitamin A results in epithelial disorders and a compromised immune system.

Toxicity Symptoms

The condition created by excessive vitamin A intake is called *hypervitaminosis A*. Symptoms of this toxicity include joint pain, thickening of long bones, loss of hair, and jaundice. Excessive vitamin A also may cause liver injury with the following two results: (1) *portal hypertension*, which is elevated blood pressure in the blood circulation going directly to the liver from the GI tract, carrying absorbed nutrient loads after meals; and (2) *ascites*, which is fluid accumulation in the abdominal cavity.

Food Sources

Fish-liver oils, liver, egg yolk, butter, and cream are sources of preformed, natural vitamin A. Fat-soluble vitamin A only occurs naturally in the fat part of milk. Low-fat and nonfat milks and the butter substitute margarine are good sources of vitamin A because they are fortified with added vitamin A. Some good sources of beta-carotene are dark green leafy vegetables such as Swiss chard, turnip greens, kale, and spinach; and dark orange vegetables and fruits such as carrots, sweet potatoes or yams, pumpkin, mango, and apricots. Both beta-carotene and preformed vitamin A require the presence of bile salts for proper absorption from the intestine. Bile acts as an antioxidant to protect and stabilize the easily oxidized vitamin, as well as transport it through the intestinal wall. Table 7-1 provides some comparative food sources of vitamin A.

Stability

Retinol is unstable in heat and in contact with air. Cooking vegetables in an uncovered pot destroys much of their vitamin content. Quicker cooking with little water helps to preserve the vitamins. If fats are rancid or vegetables are wilted, most of the vitamin A is destroyed.

VITAMIN D (CHOLECALCIFEROL)

Vitamin D is not actually a true vitamin because it is made in our own bodies with the help of the sun's ultraviolet rays. It was mistakenly classed as a vitamin by its discoverers in 1922 because they were able to cure the childhood deficiency disease, rickets, with its only known natural form in fish liver oils. Today we know that the compound made in our skin by sunlight is actually a **prohormone**. This irradiated compound in the skin has been given the name **cholecalciferol**, often shortened to *calciferol*, because it is a fat-soluble *sterol* that controls calcium metabolism in bone-building. The initial compound in the skin is a *cholesterol* base. The irradiated cholesterol base in the skin, calciferol, is then activated by two successive enzymes, first in the liver and then in the kidney, to become the active

carotene a group name of three red and yellow pigments (alpha-, beta-, and gamma-carotene) found in dark green and yellow vegetables and fruits. The one most important to human nutrition is beta-carotene because the body can convert it to vitamin A, thus making it a primary source of the vitamin.

prohormone a precursor substance that the body converts to a hormone. For example, a cholesterol compound in the skin is first irradiated by sunlight and then converted through successive enzyme actions in the liver and kidney into the vitamin D hormone, which then regulates calcium absorption and bone development. Only a few food sources of vitamin D are found in food fats (e.g., cream, butter, and egg yolks), but vitamin D occurs in other processed foods (e.g., breakfast cereals and milk) through enrichment.

cholecalciferol the chemical name for vitamin D in its inactive dietary form; often shortened to calciferol.

vitamin D hormone form called **calcitriol** that functions in the body.

Functions

Calcitriol performs the following functions in the body.

Absorption of Calcium and Phosphorus

The hormone form calcitriol acts physiologically with two other hormones, the *parathyroid hormone* (PTH) and the thyroid hormone *calcitonin*. In balance with these two hormones, the vitamin D hormone stimulates absorption of calcium and phosphorus in the small intestine.

Bone Mineralization

Calcitriol also works with calcium and phosphorus to form bone tissue by directly regulating the rate of deposit and resorption of these minerals in bone. This balancing process builds and maintains bone tissue. Thus calcitriol has been clinically used to treat *osteoporosis*, which is a type of bone loss that leads to brittle bones and spontaneous fractures.

Requirements

A number of factors influence our requirements for vitamin D, and excessive intake is possible, especially in young infants. It is difficult to set requirements for this nutrient because of its unique hormonelike nature, its synthesis in the skin by the sun's irradiation of cholesterol there, and its limited food sources. The amount needed may vary between winter and summer, and with individual exposure to sunlight. People regularly exposed to sunlight (e.g., under appropriate conditions) have no dietary requirement for vitamin D. A substantial proportion of the U.S. population, however, is exposed to very little sunlight, especially during certain seasons, so a dietary supply is needed. The DRI research does not establish an RDA figure for vitamin D. Instead, adequate intake (AI) levels are given as guidelines. For example, the AI is 5 μg per day (200 IU) for both women and men from birth to age 5. The DRIs also set the upper limit (UL) for vitamin D for persons over age 1 at 50 μg per day.

Deficiency Disease

A deficiency of calcitriol causes **rickets**, a condition characterized by malformation of skeletal tissue in growing children (Figure 7-1). Children with rickets have soft long bones that bend under the weight of the child.

Figure 7-1 Child with rickets. Note his bowlegs. (From McLaren DS: *A colour atlas and text of diet-related disorders*, ed [illegible], London, 1992, Mosby Year Book Europe Limited.)

Toxicity Symptoms

Excess intake of vitamin D, especially in infants, can [illegible] toxic. Symptoms of toxicity, or *hypervitaminosis D*, inclu[illegible] calcification of soft tissues such as kidneys and lungs, as we[illegible] as fragile bones. Prolonged intake of cholecalciferol (e.g., above 50 μg/day [2000 IU], which is 10 times the AI guide[illegible] line) can produce elevated levels of calcium in the blood [illegible] infants and calcium deposits in the kidney nephrons [illegible] both infants and adults, affecting overall kidney functio[illegible] For example, infant feeding may provide an excess (e.g., [illegible] much as 100 μg [4000 IU] or more) of cholecalciferol whe[illegible] fortified milk and fortified cereal are used in addition [illegible] variable vitamin supplements. An infant (from birth [illegible] 1 year) only needs 5 μg (200 IU) of cholecalciferol daily

Food Sources

Only yeast and fish liver oils are natural sources of vi[illegible] tamin D. Therefore the only regular food sources [illegible] vitamin D are those that have been fortified with the

TABLE 7-2 Significant Food Sources of Vitamin D

Food item	Quantity	Vitamin D (µg)
BREAD, CEREAL, RICE, PASTA		
Corn flake cereal	1 cup (1 oz)/28 g	1
Granola	¼ cup (1 oz)/28 g	1.23
Raisin and bran cereal	½ cup (1 oz)/28 g	1.23
VEGETABLES		
This food group is not an important source of vitamin D.		
FRUITS		
This food group is not an important source of vitamin D.		
MEAT, POULTRY, FISH, DRY BEANS, NUTS		
This food group is not an important source of vitamin D.		
EGGS		
Egg, whole	1 large/50 g	0.68
Egg yolk	Yolk of 1 large egg/17 g	0.68
MILK, DAIRY PRODUCTS		
Evaporated milk, vitamin D-fortified	½ cup (4 fl oz)/126 g	2.50
Milk, whole or nonfat, vitamin D-fortified	1 quart/960 g	10
Milk, whole or nonfat, vitamin D-fortified	1 cup (8 fl oz)/240 g	2.50
FATS, OILS, SUGAR		
Margarine	1 Tbsp	1.50
Fish oil	1 Tbsp	34

vitamin (Table 7-2). Because it is a common food and also contains calcium and phosphorus, milk is the most practical carrier. The standard commercial practice is to add 10 µg (400 IU)/quart. But dairies and other producers must be closely regulated to ensure that this practice is consistently accurate (see the For Further Focus box "Vitamin D Toxicity: Too Much of a Good Thing"). Butter substitutes, such as margarines, are also fortified. Children on vitamin D-deficient diets (e.g., a rigid macrobiotic pattern with no milk products) are especially vulnerable to stunted bone development and rickets.

Stability

Vitamin D is stable to heat, aging, and storage.

VITAMIN E (TOCOPHEROL)

Early vitamin studies identified a substance necessary for animal reproduction that was chemically an alcohol. This substance was named **tocopherol**, from two Greek words: *tophos*, meaning "childbirth," and *phero*, meaning "to bring," with the *-ol* ending for alcohol. Tocopherol soon became known as the antisterility vitamin, but it was soon demonstrated to have this effect only in rats and a few other animals, not in humans; all advertising claims for its contribution to sexual powers notwithstanding. A number of related compounds have since been discovered. Tocopherol (vitamin E) is actually the generic name for a group of similar fat-soluble nutrients. Three of these, designated alpha (α)-, beta (β)-, and gamma (γ)-tocopherol, display the most biological

calcitriol the activated hormone form of vitamin D.

rickets (Gr. *rhachitis*, a spinal complaint) a disease of childhood characterized by softening of the bones from an inadequate intake of vitamin D and insufficient exposure to sunlight; also associated with impaired calcium and phosphorus metabolism.

tocopherol (Gr. *tokos*, childbirth; *pherein*, to carry) the chemical name for vitamin E, which was so named by early investigators because their initial work with rats indicated a reproductive function, which is not true with humans. In humans, vitamin E functions as a strong antioxidant that preserves structural membranes such as cell walls.

FOR FURTHER FOCUS

Vitamin D Toxicity: Too Much of a Good Thing

In the United States, milk has been fortified with vitamin D since the early 1930s. As a result, rickets largely has been eradicated. From the beginning, U.S. federal regulations have specified that each quart of milk contain 10 μg (400 IU) of vitamin D. The previous measure of International Units (IU) is passing from use in relation to vitamin needs because it is a less useful measure than the metric unit micrograms (μg), which can be measured and regulated directly.

Toxic amounts of vitamin D, however, can build up in the body easily because this vitamin is stored in fat tissue and released slowly. Even today, cases of toxicity occur, usually from excessively fortified milk. For example, a U.S. outbreak was traced to a local dairy's sporadic addition, ranging from 20 μg to nearly 6000 μg/quart, of excessive vitamin D to milk during the fortification process, even though the regulation calls for only 10 μg. Young children who drank this dairy's milk for several years did not grow normally in height and developed kidney function problems because of excess calcium in their kidney tissues. Adults suffered progressive weakness, elevated blood levels of calcium, and bone pain.

For the most part, the American dairy industry is diligent about using correct procedures for fortifying milk, but this case demonstrated that too much of an essential vitamin can cause illness.

activity. Of these three, α-tocopherol is the most significant in human nutrition and thus is used for measuring dietary needs.[2]

Functions

The most vital function of tocopherol is its action as an antioxidant in many tissues. An antioxidant is an agent that prevents cellular structure from being broken down by oxygen (e.g., the process of oxidation).

Antioxidant Function

Tocopherol acts as nature's most potent fat-soluble antioxidant. The polyunsaturated fatty acids (see Chapter 3) in lipid membranes of body tissues are particularly easy for oxygen to break down. Tocopherol can interrupt this oxidation process, protecting the fatty acids of the cell membrane from damage. For example, vitamin E can protect fragile red blood cell walls in premature infants from breaking down, causing anemia (see the Clinical Applications box, "Vitamin E and Premature Infants"). Vitamin E helps protect both red blood cells and muscle tissue cells.

Relation to Selenium Metabolism

Selenium is a trace mineral that works as a partner with tocopherol as an antioxidant. A selenium-containing enzyme, glutathione peroxidase, is the second line of defense in preventing oxidative damage to cell membranes. Selenium spares tocopherol by reducing its requirement, just as tocopherol does for selenium.

Requirements

Tocopherol requirements are expressed in terms of *alpha-tocopherol* in mg/day. The DRI recommendations state that the RDA standard for men and women age 14 and older is 15 mg/day, with lesser amounts necessary during childhood. Needs during the first year of infancy do not have an RDA figure, but an AI amount of 4 to 6 mg/day is used. The UL for all adults is set at 1000 mg/day.

Deficiency Disease

Young infants, especially premature infants who miss the final 1 to 2 months of gestation when tocopherol stores are normally built up, are particularly vulnerable to the tocopherol deficiency disease called hemolytic anemia. In this disease, the lipid membranes of red blood cells are easily oxidized by oxygen, and the continued loss of red blood cells leads to anemia. In older children and adults, a deficiency of tocopherol disrupts normal synthesis of *myelin*, the protective fat covering of nerve cells that helps them pass messages along to specific tissues. The main nerves involved are the following: (1) spinal cord fibers that affect physical activity (e.g., walking), and (2) the retina of the eye that affects vision.

Toxicity Symptoms

Tocopherol from food sources has no known toxic effect in humans. Supplemental intakes exceeding the UL of 1000 mg/day may interfere with vitamin K activity and blood clotting.

CLINICAL APPLICATIONS

Vitamin E and Premature Infants

A medical problem found in infants, especially premature ones, has responded positively to vitamin E therapy. This problem is hemolytic anemia.

Anemia is a blood condition characterized by loss of mature, functioning red blood cells. Different types of anemia are usually named according to cause or to the nature of an abnormal nonfunctioning cell produced. The name of this type of anemia comes from its cause. The word hemolysis comes from two roots: *hemo*, referring to blood, and *lysis*, meaning dissolving or breaking. Therefore hemolysis means the bursting or dissolving of red blood cells, and the resulting condition is hemolytic anemia. Vitamin E can help prevent this destruction of red blood cells and the loss of their vital oxygen-carrying hemoglobin because it is one of the body's foremost antioxidants.

An oxidant is a compound or oxygen itself that oxidizes other compounds, thereby breaking them down or changing them. Vitamin E is readily oxidized. When there is plenty of vitamin E among the other compounds exposed to an oxidant, vitamin E can, by its nature, take on the oxidative attack, thus protecting the others. Vitamin E is fat soluble, so it is found among the polyunsaturated fatty acids that compose the core of the cell membranes in body tissues that are rich in fat. The cell membranes of red blood cells are particularly rich in these polyunsaturated lipids and are exposed to concentrated oxygen because they constantly circulate through the lungs. This situation would be destructive to the red blood cells if vitamin E was not present. Vitamin E takes the oxygen itself, protecting the polyunsaturated fatty acids and keeping the red blood cells intact to continue their life-sustaining journey throughout the body. Thus vitamin E acts as nature's most potent fat-soluble antioxidant. It interrupts the oxidative breakdown by free radicals (e.g., parts of compounds broken off by cell metabolism) in the cell, protecting the cell membrane fatty acids from the oxidative damage.

The protective need of vitamin E is especially great in small, premature infants fed formulas containing iron, which acts as an oxidant, and high concentrations of polyunsaturated fatty acids, which are vulnerable to oxidative breakdown. To avoid this problem and comply with American Academy of Pediatrics recommendations, manufacturers have increased the amount of vitamin E and lowered the iron in formulas for premature infants. The proportions of vitamin E, polyunsaturated fatty acids, and iron in today's improved formulas usually supply enough necessary nutrients, so in most cases supplements are no longer necessary to prevent hemolytic anemia in premature infants.

Food Sources

The richest sources of tocopherol are vegetable oils (wheat germ, soybean, and safflower oil). Note that vegetable oils are also the richest sources of polyunsaturated fatty acids, which vitamin E protects. Other food sources of tocopherol include nuts, fortified cereals, and avocado. Table 7-3 provides a list of vitamin E food sources.

Stability

Tocopherol is stable to heat and acids but not to alkalis.

VITAMIN K

In the early era of vitamin research Henrik Dam, a biochemist at the University of Copenhagen, discovered a hemorrhagic disease in chicks that were fed a fat-free diet and determined that the factor responsible was the absence of a fat-soluble, blood-clotting vitamin. He called it "koagulationsvitamin," or vitamin K, and the letter name has stuck. Dam later succeeded in isolating and identifying the agent from alfalfa, for which he received the Nobel prize for physiology and medicine. As with a number of vitamins, not one but several forms of vitamin K compose a group of substances with similar biologic activity in blood clotting. The major form found in plants, and initially isolated from alfalfa by Dam, is named **phylloquinone** because of its chemical structure. Phylloquinone is our dietary form of

phylloquinone a fat-soluble vitamin of the K group found in green plants or prepared synthetically.

TABLE 7-3 Significant Food Sources of Vitamin E as Alpha-Tocopherol

Food item	Quantity	Vitamin E (mg α-TE)
BREAD, CEREAL, RICE, PASTA		
This food group is not an important source of vitamin E.		
VEGETABLES		
Asparagus, raw	4 spears/58 g	1.15
Avocado, raw	1 medium/173 g	2.32
Brussels sprouts, boiled	½ cup (4 sprouts)/78 g	0.66
Cabbage, green, raw	½ cup, shredded/35 g	0.58
Carrot, raw	1 medium/72 g	0.32
Lettuce, iceberg, raw	¼ head/135 g	0.54
Spinach, raw	½ cup, chopped/28 g	0.53
Sweet potato, raw	1 medium/130 g	5.93
FRUITS		
Apple, raw, with skin	1 medium/138 g	0.81
Apricot, canned	4 halves/90 g	0.80
Avocado	½ medium/86.5 g	1.70
Banana, raw	1 medium/114 g	0.31
Mango, raw	1 medium/207 g	2.32
Pear, raw	1 medium/166 g	0.83
MEAT, POULTRY, FISH, DRY BEANS, EGGS		
This food group is not an important source of vitamin E.		
NUTS		
Almonds, dried	1 oz (24 nuts)/28 g	6.72
Hazelnuts, dried	1 oz/28 g	6.70
Peanut butter	1 Tbsp/16 g	3
Peanuts, dried	1 oz/28 g	2.56
Walnuts, dried	1 oz (14 halves)/28 g	0.73
MILK, DAIRY PRODUCTS		
This food group is not an important source of vitamin E.		
FATS, OILS, SUGAR		
Corn oil	1 Tbsp/14 g	1.90
Cottonseed oil	1 Tbsp/14 g	4.80
Olive oil	1 Tbsp/14 g	1.60
Palm oil	1 Tbsp/14 g	2.60
Peanut oil	1 Tbsp/14 g	1.60
Safflower oil	1 Tbsp/14 g	4.60
Soybean oil	1 Tbsp/14 g	1.50

α TE, α-Tocopherol equivalents.

vitamin K, while menaquinone, a second form, is synthesized by intestinal bacteria. Menaquinone contributes about half of our daily supply of vitamin K.

Functions

Vitamin K is known to have two metabolic functions in the body: blood clotting and bone development.

Blood Clotting

The basic function of vitamin K is in the blood-clotting process. Vitamin K is essential for maintaining normal levels of four of the 11 blood-clotting factors. The most familiar of these vitamin K-dependent blood factors is *prothrombin* (number II). Thus phylloquinone can serve as an antidote for the excess effects of anticoagulant drugs. Phylloquinone is often used in the control and prevention of certain types of hemorrhages. Because this fat-soluble vitamin is absorbed more completely if bile is present, conditions that hinder bile flow to the small intestine reduce blood-clotting ability. If bile salts are given with vitamin K concentrate, the blood-clotting time returns to normal.

Bone Development

A more recently discovered function of vitamin K relates to bone development. Specific proteins found in bone and bone matrix are dependent on vitamin K for their synthesis and are involved with calcium in bone development. Like the blood-clotting proteins, these bone proteins bind calcium but function here to form bone crystals.

Requirements

Because intestinal bacteria synthesize a form of vitamin K, a constant supply is normally available to support dietary sources. Currently, there is not enough scientific evidence available to establish an RDA.[3] Therefore the DRIs for vitamin K are represented by an AI value. Values gradually increase from birth to adulthood. The AI standard for men is 120 μg/day and 90 μg/day for women. A recent study indicates that men and women in the 18- to 44-year-old age group reported dietary intakes below the current recommended intakes.[4]

Deficiency Disease

Deficiency disease relating to vitamin K is not usually found in humans. A deficiency is unlikely except in clinical conditions related to blood clotting, malabsorption, or lack of intestinal bacteria to synthesize the vitamin. For example, because the intestinal tract of a newborn is sterile, phylloquinone is routinely given to prevent hemorrhage when the umbilical cord is cut. The "vitamin K shot" giving at birth is commonly called AquaMephyton, Mephyton, or Phytonadione. Patients with severe malabsorption disorders, such as Crohn's disease, or who are placed on poor diets after surgery and treated with antibiotics that kill intestinal bacteria, are susceptible to vitamin K deficiency with resulting blood loss and poor wound healing.

Toxicity Symptoms

Toxicity from vitamin K—even when large amounts are taken over extended periods—has not been observed.

Food Sources

Green leafy vegetables, which provide 50 to 800 μg of phylloquinone per 100 g of food, are clearly the best dietary sources. Small amounts of phylloquinone are contributed by milk and dairy products, meats, fortified cereals, fruits, and vegetables (Table 7-4).

Stability

Vitamin K as phylloquinone is fairly stable, although it is sensitive to light and irradiation. Therefore clinical preparations are kept in dark bottles.

Table 7-5 provides a summary of the fat-soluble vitamins.