Vitamin A and Nutrition

Vitamin A (retinoids) refers to three pre-formed compounds that exhibit metabolic activity: the alcohol (retinol), the aldehyde (retinal or retinaldehyde), and the acid (retinoic acid). Stored retinol is often esterified to a fatty acid, usually retinyl-palmitate, which is usually found complexed with food proteins. The active forms of vitamin A exist only in animal products. In addition to pre-formed vitamin A found in animal products, plants contain a group of compounds known as carotenoids, which can yield retinoids when metabolized in the body. Although several hundred carotenoids exist in foods naturally as antioxidants, only a few have, significant vitamin A activity. The most important of these is B-carotene. The amount of vitamin A available from dietary carotenoids depends on how well they are absorbed and how efficiently they are converted to retinol. Absorption varies greatly (from 5 % to 50 %) and is affected by other dietary factors such as the digestibility of the proteins complexed with the carotenoids and the level and type of fat in the diet.

Absorption, Transport, and Storage

Before either vitamin A or its carotenoid provitamins can be absorbed, proteases in the stomach and small intestine must hydrolyze proteins that are usually complexed with these compounds. In addition, retinyl esters must be hydrolyzed in the small intestine by lipases to retinol and free fatty acids. Retinoids and carotenoids are incorporated into micelles along with other lipids for passive absorption into the mucosal cells of the small intestine. Once in the intestinal mucosal cells, retinol is bound to a cellular retinol-binding protein (CRBP) and reesterified, primarily by lecithin retinol acyl transferase into retinyl esters. Carotenoids and retinyl esters are then incorporated into chylomicrons for transport into the lymph and eventually the bloodstream. They may also be cleaved into retinal, which is then reduced to retinol and reesterified into retinyl esters to be incorporated into chylomicrons.

The liver plays an important role in vitamin A transport and storage . Chylomicron remnants deliver retinyl esters to the liver. These esters are immediately hydrolyzed into retinol and free fatty acids. Retinol in the liver has three major metabolic fates. First, retinol may be bound to CRBP, which controls free retinol concentrations that can be toxic in the cell. Second, retinol may be reesterfied to form retinyl palmitate for storage. Approximately 50 % to 80 % of the vitamin A in the body is stored in the liver. Adipose tissue, lungs, and kidneys also store retinyl esters in specialized cells called stellate cells. This storage capacity buffers the effects of highly variable patterns of vitamin A intake and is particularly important during periods of low intake when a person is at risk for developing a deficiency Finally, retinol may be bound to retinol-binding protein (RBP). Retinol bound to RBP leaves the liver and enters the blood, where the transthyretin (TTR) protein attaches and forms a complex to transport retinol in the blood to the peripheral tissues. Because hepatic RBP synthesis depends on adequate protein, protein deficiency affects retinol levels along with vitamin A deficiency. Thus individuals with PCM typically have low circulating retinol levels that may not respond to vitamin A supplementation until protein deficiency is also corrected. The retinol-RBP-TTR complex delivers retinol to other tissues via cell surface receptors. Retinol is transferred from RBP to CRBP with the subsequent release of Apo RBP into binding protein and TTR to the blood. Apo RBP is eventually metabolized and excreted by the kidney. In addition to CRBP, cellular retinoic acid-binding proteins (CRABPs) bind retinoic acid in the cell and serve to control retinoic acid concentrations similar to the way CRBP controls retinol concentrations.

Metabolism

In addition to being esterified for storage, the transport form of retinol can also be oxidized into retinal and then into retinoic acid or conjugated into retinyl glucuronide or phosphate. After retinoic acid is formed, it is converted to forms that are readily excreted.

Chain-shortened and oxidized forms of vitamin A are excreted in the urine; intact forms are excreted in the bile and feces.

Dietary Reference Intakes Measurememt

The vitamin A content of foods is measured as retinol activity equivalents (RAEs). One RAE equals the activity of I mcg of retinol (1 mcg of retinol is equal to 3.33 International Units) . The efficiency of B-carotene absorption is lower (14 %) than previously believed (33 %) . In developed countries, 12 mcg of B-carotene is equal to 1 RAE, and 24 mcg of other carotenoids equal 1 RAE. The rate in developing countries is less efficient, requiring at least 21 molecules of ß-carotene to get 1 molecule of vitamin A. Dietary reference intakes (DRIs) have been determined for vitamin A and are expressed in micrograms per day (mcg/day). The AI for infants is based on the amount of retinol in human milk. The DRIs for adults are based on levels that provide adequate blood levels and liver stores and are adjusted for differences in average body size Increased amounts of the vitamin during pregnancy and lactation allow for fetal storage and the vitamin A in breast milk. No DRIs have been established for the carotenoids. Indeed, while supplementation may be harmful, increased consumption of fruits and vegetables containing carotenoids is clearly beneficial.

Sources

Pre-formed vitamin A exists only in foods of animal origin either in storage areas such as the liver or in the fat of milk and eggs. Very high concentrations of vitamin A are found in cod and halibut liver oils. Nonfat milk in the United States, which by US. law can contain 0.1 % fat, is routinely fortified with retinol.. Provitamin A carotenoids are found in dark green, leafy and yellow-orange vegetables and fruit; deeper colors are associated with higher carotenoid levels. In much of the world, carotenoids supply most of the dietary vitamin A. The American food supply provides roughly equal amounts of pre-formed vitamin A and provitamin A carotenoids. Carrots, greens, spinach, orange juice, sweet potatoes, and cantaloupe are rich sources of provitamin A. In many of these foods, vitamin A bioavailability is limited by binding of carotenoids to proteins; this can be overcome by cooking, which disrupts the protein association and frees the carotenoid.