

## Vitamin A

### Physiological Functions

Vitamin A includes several bioactive compounds known as **retinoids** as well as precursor forms of the vitamin (provitamin A) known as **carotenoids**. Retinoids (retinol, retinal, and retinoic acid) are preformed vitamin A obtained primarily from foods of animal origin, but are also found in some fortified foods. Carotenoids are yellow-orange pigments found only in foods of plant origin where they are closely associated with chlorophyll.

Vitamin A activity is measured relative to retinol, i.e., retinal equivalents. Retinol, the most reduced form of the vitamin, satisfies requirements for all known functions of vitamin A. It may be reversibly oxidized to retinal, the active form in visual functions involving rods and cones of the retina, but is irreversibly oxidized to retinoic acid, the active form for epithelial and skeletal functions. Retinol is transported through the blood bound to retinal-binding protein and is stored in the liver bound to a protein. Synthesis of retinal-binding protein is dependent on zinc.

The provitamin A carotenoids, alpha and beta carotene, are converted in part to retinol primarily in the intestines and lungs. Additional amounts are utilized as antioxidants to quench energy from photosensitized oxygen free radicals. Amounts absorbed in excess of vitamin A or antioxidant needs are stored in subcutaneous fat. Other carotenoids, such as lutein and lycopene, have no vitamin A activity and are utilized only for their antioxidant capacity. Of the approximately 600 carotenoids that occur in nature, 90% are not precursors of vitamin A. However, these carotenoids are powerful antioxidants with greater protective effects against free radical damage than beta carotene.

### Factors Affecting Availability

Because vitamin A is a fat-soluble vitamin, it must be incorporated into micelles in a bile-dependent reaction before it can be absorbed. Consequently, dietary fat must be consumed with sources of vitamin A to insure adequate absorption. Very low-fat intakes (<15% of total energy) reduce bioavailability of vitamin A. Intakes of mineral oil or commercial fat replacers (e.g., Olestra®) inhibit vitamin A absorption by solubilizing the vitamin in nonabsorbable media. Other substances which may adversely affect vitamin A availability include high doses of ferrous sulfate (iron supplement), tannic acid (black tea), aspirin, and nitrates from processed meats.

Vitamin A is heat-stable with 70-90% retention during cooking over a wide range of temperatures. The bioavailability of beta-carotene and other carotenoids increases several-fold during cooking because heat releases these substance from proteins to which they are bound in foods. The addition of oils or other fats to carrots, greens or other carotenoid-rich foods during cooking will optimize absorption. However, since fat is emptied from the stomach slowly, it does not need to be consumed at the same time as

low fat sources of carotenoids. Because retinol is found in foods of animal origin, some fat is usually present when these sources are consumed.

### **Deficiency**

Insufficient vitamin E may reduce bioavailability of vitamin A by increasing the susceptibility of retinol to oxidation. Inadequate intakes of zinc, iron and protein may also reduce availability of vitamin A by interfering with plasma transport and release of the vitamin from its hepatic stores. Conditions associated with increased risk of vitamin A deficiency are alcoholism (by precipitating zinc deficiency), celiac disease, fat malabsorption disorders, and respiratory disease. Lifestyle factors that may contribute to poor vitamin A status include use of tobacco products that increase demand for the vitamin and frequent consumption of fast food, commercial snack foods, and sweets that replace fruits and vegetables in the diet.

The early stages of vitamin A deficiency are characterized by impaired dark adaptation that will progress, if uncorrected, to nyctalopia (night blindness) and xerophthalmia. Changes in skin (follicular hyperkeratosis) and salivary gland atrophy are also noted in early stage deficiency of the vitamin. Other effects of Vitamin A deficiency include impaired wound healing, abnormal skeletal development in children, and increased risk of infection, particularly of respiratory origin.

### **Toxicity**

Approximately 80% of the total body pool of vitamin A is found in the liver. Excessive intake of the vitamin (1000 times more than that required) can promote cheilitis (dry lips) as well as dryness of nasal mucosa, eyes, and skin, hair loss, and nail fragility. Other clinical indices of vitamin A toxicity include bone pain, gingivitis, hepatomegaly and ascites. Serum retinol levels of 250-6600 IU/100mL are an indicator of toxicity.

Hypervitaminosis A can be triggered acutely by a single dose of a supplement if it contains 660,000 IU. Chronic hypervitaminosis A can also develop if supplements containing >33,000 IU of Vitamin A are consumed on a regular basis.

Consumption of large amounts of carotenoids will not contribute to vitamin A toxicity since efficiency of absorption decreases with dosage, and conversion to the vitamin is not rapid enough to contribute to toxic levels. Hypercarotenosis characterized by yellowish skin coloration may be observed with high doses of carotenoids.

Retinoids obtained from supplements and medications are teratogenic and thus use of these products are contraindicated during pregnancy. Carotenoids are not teratogenic.

- ❖ *The upper safety limit for vitamin A established by the Food and Nutrition Board of the Institute of Medicine is approximately 3,000 mcg daily when provided as retinol in animal foods, fortified products or vitamin supplements).*

<b>Vitamin A Tolerable Upper Intake Levels</b>	
Life Stage	Vitamin A (mcg/day)
<b>Infants</b>	
0-6 mo	600
7-12 mo	600
<b>Children</b>	
1-3 y	600
4-8 y	900
<b>Males, Females</b>	
9-13 y	1700
14-18 y	2800
19-70 y	3000
70 y	2000
<b>Pregnancy</b>	
< 18 y	1800
19-50 y	2000
<b>Lactation</b>	
< 18 y	2800
19-50 y	3000

## Requirements

The Daily Reference Intakes (DRI) established for vitamin A are found in the table below.

<b>Vitamin A Requirements Daily Reference Intakes</b>	
Life Stage	Vitamin A (mcg/day)
<b>Infants</b>	
0-6 mo	400
7-12 mo	500
<b>Children</b>	
1-3 y	300
4-8 y	400
<b>Males</b>	
9-13 y	600
14-18 y	900
19-30 y	900
31-50 y	900
51-70 y	900
70 y	900
<b>Females</b>	
9-13 y	600
14-18 y	700
19-30 y	700
31-50 y	700
51-70 y	700
70	700
<b>Pregnancy</b>	

18 y	750
19-30 y	770
31-50 y	770
Lactation	
18 y	1200
19-30 y	1300
31-50 y	1300

## Dietary Sources

Dark orange, yellow, red fruits and vegetables are rich sources of beta-carotene and other carotenoids. Since these pigments are also found in chlorophyll-rich plants which mask the orange color, dark green leafy vegetables are also rich sources of carotenoids.

Retinol is found in whole milk, butter, cheese or other dairy products and in beef and chicken liver. It is added as retinyl palmitate or other retinyl esters to cereals, skim milk and margarine.

Although vitamin A requirements are given in  $\mu\text{g}$  of retinol equivalents (RE), vitamin A content of foods appears on the label in International Units (IU). The conversion of IU to retinol equivalents is made using conversion factors that depend on the source.

### One Retinol Equivalent (RE) of Vitamin A (in $\mu\text{g}$ ) =

- 6 International Units (IU) from beta-carotene
- 10 IU from other carotenoid-rich plant foods
- 4.10 IU from milk and yogurt
- 3.33 IU from animal sources and fortified foods

Vitamin A Rich Foods	
FOOD	Vitamin A ( $\mu\text{g}$ RE)
Liver, beef, 3.5 oz	10602
Chicken liver, 3.5 oz	4,900
Pumpkin, canned, 1/2 cup	2700
Carrots, raw, 7.5" long	2025
Carrots, baby, 12 raw	1800
Sweet potato, baked, 1 small	1310
Squash, butternut, _ cup	857
Mango, fresh, one	805
Spinach, cooked, _ cup	739
Spinach, fresh, 1 cup raw	202
Cantaloupe, 1 cup	561
Apricots, fresh, 4 halves	366
Apricots, dried, 4 large halves	101
Collard greens, 1/2 cup fresh/cooked	502
Kale, 1/2 cup cooked	481
Vegetable-tomato juice, 1 cup	283
Broccoli, _ cup cooked	174
Romaine lettuce, 1 cup fresh	146
Skim milk, Vitamin A fortified, 1 cup	149

