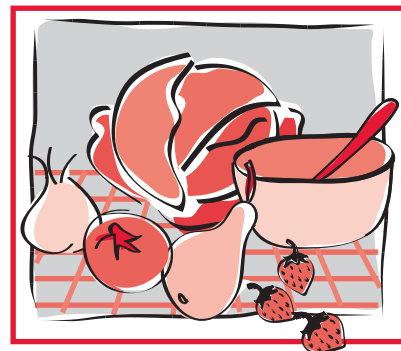


### Water-Soluble Vitamins: B-Complex and Vitamin C

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#### What are Vitamins?

Vitamins are essential nutrients found in foods. They perform specific and vital functions in a variety of body systems, and are crucial for maintaining optimal health.

The two different types of vitamins are fat-soluble vitamins and water-soluble vitamins. Fat-soluble vitamins — vitamins A, D, E and K — dissolve in fat before they are absorbed in the bloodstream to carry out their functions. Excesses of these vitamins are stored in the liver, and are not needed every day in the diet. For more information on fat-soluble vitamins, see fact sheet [9.315 Fat-Soluble Vitamins: A, D, E, and K](#).

In contrast, water-soluble vitamins dissolve in water and are not stored by the body. Since they are eliminated in urine, we require a continuous daily supply in our diet. The water-soluble vitamins include the vitamin B-complex group and vitamin C.

Water-soluble vitamins are easily destroyed or washed out during food storage or preparation. Proper storage and preparation of food can minimize vitamin loss. To reduce vitamin loss, always refrigerate fresh produce, keep milk and grains away from strong light, and use cooking water from vegetables to prepare soups.

#### What are Water-Soluble Vitamins?

##### B-complex Vitamins

Eight of the water-soluble vitamins are known as the vitamin B-complex group: thiamin (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3), vitamin B6 (pyridoxine), folate (folic acid), vitamin B12, biotin and pantothenic acid. The B vitamins are widely distributed in foods,

and their influence is felt in many parts of the body. They function as coenzymes that help the body obtain energy from food. The B vitamins are also important for normal appetite, good vision, and healthy skin, nervous system, and red blood cell formation.

##### Thiamin: Vitamin B1

*What is Thiamin.* Thiamin, or vitamin B1, helps to release energy from foods, promotes normal appetite, and is important in maintaining proper nervous system function.

*Food Sources for Thiamin.* Sources include peas, pork, liver, and legumes. Most commonly, thiamin is found in whole grains and fortified grain products such as cereal, and enriched products like bread, pasta, rice, and tortillas. The process of enrichment adds back nutrients that are lost when grains are processed. Among the nutrients added during the enrichment process are thiamin (B1), niacin (B3), riboflavin (B2), folate and iron.

*How much Thiamin.* The Recommended Dietary Allowance (RDA) for thiamin is 1.2 mg/day for adult males and 1.1 mg/day for adult females (Table 1). These values are closely tied to calorie expenditure.

*Thiamin Deficiency.* Under-consumption of thiamin is rare in the United States due to wide availability of enriched grain products. However, low calorie diets as well as diets high in refined and processed carbohydrates may place one at risk for thiamin deficiency. Alcoholics are especially prone to thiamin deficiency because excess alcohol consumption often replaces food or meals. Symptoms of thiamin deficiency include: mental confusion, muscle weakness, wasting, water retention (edema), impaired growth, and the disease known as beriberi. Thiamin deficiency is currently not a problem in the United States.

*Too much Thiamin.* No problems with overconsumption are known for thiamin.

#### Quick Facts

- B-complex vitamins and vitamin C are water-soluble vitamins that are not stored in the body and must be replaced each day.
- These vitamins are easily destroyed or washed out during food storage and preparation.
- The B-complex group is found in a variety of foods: cereal grains, meat, poultry, eggs, fish, milk, legumes and fresh vegetables.
- Citrus fruits are good sources of vitamin C.
- Using megadoses of multivitamins or supplements is not recommended.

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### **Riboflavin: Vitamin B2**

*What is Riboflavin.* Riboflavin, or vitamin B2, helps to release energy from foods, promotes good vision, and healthy skin. It also helps to convert the amino acid tryptophan (which makes up protein) into niacin.

*Food Sources for Riboflavin.* Sources include liver, eggs, dark green vegetables, legumes, whole and enriched grain products, and milk. Ultraviolet light is known to destroy riboflavin, which is why most milk is packaged in opaque containers instead of clear.

*How much Riboflavin.* The Recommended Dietary Allowance (RDA) for riboflavin is 1.3 mg/day for adult males and 1.1 mg/day for adult females (Table 1). Like thiamin, these values are closely tied to energy expenditure.

*Riboflavin Deficiency.* Under consumption of riboflavin is rare in the United States. However, it has been known to occur with alcoholism, malignancy, hyperthyroidism, and in the elderly. Symptoms of deficiency include cracks at the corners of the mouth, dermatitis on nose and lips, light sensitivity, cataracts, and a sore, red tongue.

*Too much Riboflavin.* No problems with overconsumption are known for riboflavin.

### **Niacin: Vitamin B3, Nicotinamide, Nicotinic Acid.**

*What is Niacin.* Niacin, or vitamin B3, is involved in energy production, normal enzyme function, digestion, promoting normal appetite, healthy skin, and nerves.

*Food Sources for Niacin.* Sources include liver, fish, poultry, meat, peanuts, whole and enriched grain products.

*How much Niacin.* The Recommended Dietary Allowance (RDA) for niacin is 16 mg/day for adult males and 14 mg/day for adult females (Table 1). These values are closely tied to energy expenditure.

*Niacin Deficiency.* Niacin deficiency is not a problem in the United States. However, it is known to occur with alcoholism, protein malnourishment, low calorie diets, and diets high in refined carbohydrates. Pellagra is the disease state that occurs as a result of severe niacin deficiency. Symptoms include cramps, nausea, mental confusion, and skin problems.

*Too much Niacin.* Consuming large doses of niacin supplements may cause flushed skin, rashes, or liver damage (Table 2). Over consumption of niacin is not a problem if it is obtained through food.

### **Vitamin B6: Pyridoxine, Pyridoxal, Pyridoxamine**

*What is Vitamin B6.* Vitamin B6, otherwise known as pyridoxine, pyridoxal or pyridoxamine, aids in protein metabolism and red blood cell formation. It is also involved in the body's production of chemicals such as insulin and hemoglobin.

*Food Sources for Vitamin B6.* Sources include pork, meats, whole grains and cereals, legumes, and green, leafy vegetables.

*How much Vitamin B6.* The Recommended Dietary Allowance (RDA) for vitamin B6 is 1.3 mg/day for adult males and females through age fifty (Table 1). For infants, breast milk and most infant formulas contain enough vitamin B6.

*Vitamin B6 Deficiency.* Deficiency symptoms include skin disorders, dermatitis, cracks at corners of mouth, anemia, kidney stones, and nausea. A vitamin B6 deficiency in infants can cause mental confusion.

*Too much Vitamin B6.* Over consumption is rare, but excess doses of vitamin B6 over time have been known to result in nerve damage (Table 2).

### **Folate: Folic Acid, Folacin**

*What is Folate.* Folate, also known as folic acid or folacin, aids in protein metabolism, promoting red blood cell formation, and lowering the risk for neural tube birth defects. Folate may also play a role in controlling homocysteine levels, thus reducing the risk for coronary heart disease.

*Food Sources for Folate.* Sources of folate include liver, kidney, dark green leafy vegetables, meats, fish, whole grains, fortified grains and cereals, legumes, and citrus fruits. Not all whole grain products are fortified with folate. Check the nutrition label to see if folic acid has been added.

*How much Folate.* The Recommended Dietary Allowance (RDA) for folate is 400 mcg/day for adult males and females. Pregnancy will increase the RDA for folate to 600 mcg/day (Table 1).

*Folate Deficiency.* Folate deficiency affects cell growth and protein production, which can lead to overall impaired growth. Deficiency symptoms also include anemia and diarrhea. A folate deficiency in women who are pregnant or of child bearing age may result in the delivery of a baby with neural tube defects such as spina bifida. (Table 1).

*Too much Folate.* Over consumption of folate offers no known benefits, and may mask B12 deficiency as well as interfere with some medications (Table 2).

### **Vitamin B12: Cobalamin**

*What is B12.* Vitamin B12, also known as cobalamin, aids in the building of genetic material, production of normal red blood cells, and maintenance of the nervous system.

*Food Sources for Vitamin B12.* Vitamin B12 can only be found only in foods of animal origin such as meats, liver, kidney, fish, eggs, milk and milk products, oysters, shellfish. Some fortified foods may contain vitamin B12.

*How much Vitamin B12.* The Recommended Dietary Allowance (RDA) for vitamin B12 is 2.4 mcg/day for adult males and females (Table 1). For those over the age of fifty, the dietary guidelines recommend consuming vitamin B12 in its crystalline form (fortified foods or multivitamin).

*Vitamin B12 Deficiency.* Vitamin B12 deficiency most commonly affects strict vegetarians (those who eat no animal products), infants of vegan mothers, and the elderly. Symptoms of deficiency include anemia, fatigue, neurological disorders, and degeneration of nerves resulting in numbness and tingling. In order to prevent vitamin B12 deficiency, a dietary supplement should be taken. Some people develop a B12 deficiency because they cannot absorb the vitamin through their stomach lining. This can be treated through vitamin B12 injections.

*Too much Vitamin B12.* No problems with overconsumption of vitamin B12 are known.

### **Biotin**

*What is Biotin.* Biotin helps release energy from carbohydrates and aids in the metabolism of fats, proteins and carbohydrates from food.

*Food Sources for Biotin.* Sources of Biotin include liver, kidney, egg yolk, milk, most fresh vegetables, yeast breads and cereals. Biotin is also made by intestinal bacteria.

*How much Biotin.* The Adequate Intake (AI) for Biotin is 30 mcg/day for adult males and females (Table 1).

*Biotin Deficiency.* Biotin deficiency is uncommon under normal circumstances, but symptoms include fatigue, loss of appetite, nausea, vomiting, depression, muscle pains, heart abnormalities and anemia.

*Too much Biotin.* No problems with overconsumption are known for Biotin.

### **Pantothenic Acid**

*What is Pantothenic Acid.* Pantothenic Acid is involved in energy production, and aids in the formation of hormones and the metabolism of fats, proteins, and carbohydrates from food.

*Food Sources for Pantothenic Acid.* Sources include liver, kidney, meats, egg yolk, whole grains, and legumes. Pantothenic Acid is also made by intestinal bacteria.

*How much Pantothenic Acid.* The Adequate Intake (AI) for Pantothenic Acid is 5 mg/day for both adult males and females (Table 1).

*Pantothenic Acid Deficiency.* Pantothenic Acid deficiency is uncommon due to its wide availability in most foods.

*Too much Pantothenic Acid.* No problems with overconsumption are known for Pantothenic Acid. Rarely, diarrhea and water retention will occur with excessive amounts.

### **Vitamin C: Ascorbic Acid, Ascorbate**

#### **What is Vitamin C**

The body needs vitamin C, also known as ascorbic acid or ascorbate, to remain in proper working condition. Vitamin C benefits the body by holding cells together through collagen synthesis; collagen is a connective tissue that holds muscles, bones, and other tissues together. Vitamin C also aids in wound healing, bone and tooth formation, strengthening blood vessel walls, improving immune system function, increasing absorption and utilization of iron, and acting as an antioxidant.

Since our bodies cannot produce or store vitamin C, an adequate daily intake of this nutrient is essential for optimum

health. Vitamin C works with vitamin E as an antioxidant, and plays a crucial role in neutralizing free radicals throughout the body. An antioxidant can be a vitamin, mineral, or a carotenoid, present in foods, that slows the oxidation process and acts to repair damage to cells of the body. Studies suggest that vitamin C may reduce the risk of certain cancers, heart disease, and cataracts. Research continues to document the degree of these effects.

*Food Sources for Vitamin C.* Consuming vitamin C-rich foods is the best method to ensure an adequate intake of this vitamin. While many common plant foods contain vitamin C, the best sources are citrus fruits. For example, one orange, a kiwi fruit, 6 oz. of grapefruit juice or 1/3 cup of chopped sweet red pepper each supply enough vitamin C for one day.

*How much Vitamin C.* The Recommended Dietary Allowance (RDA) for Vitamin C is 90 mg/day for adult males and 75 mg/day for adult females (Table 1). For those who smoke cigarettes, the RDA for vitamin C increases by 35 mg/day, in order to counteract the oxidative effects of nicotine.

*Vitamin C Deficiency.* Although rare in the United States, severe vitamin C deficiency may result in the disease known as scurvy, causing a loss of collagen strength throughout the body. Loss of collagen results in loose teeth, bleeding and swollen gums, and improper wound healing. More commonly, vitamin C deficiency presents as a secondary deficiency in alcoholics, the elderly, and in smokers.

The following conditions have been shown to increase vitamin C requirements (Table 1):

- Environmental stress, such as air and noise pollution
- Use of certain drugs, such as oral contraceptives
- Tissue healing of wounds
- Growth (children from 0- 12 months, and pregnant women)
- Fever and infection
- Smoking.

*Too Much Vitamin C.* Despite being a water-soluble vitamin that the body excretes when in excess, vitamin C overdoses have been shown to cause kidney stones, gout, diarrhea, and rebound scurvy.

### **Can Vitamin C Prevent the Common Cold?**

The controversy over using mega doses of vitamin C to prevent or cure the common cold and other disorders has not been resolved. Recent studies have shown that an increased intake of vitamin C over 500 mg per day does not increase a body's overall level of vitamin C. Therefore, intake over 500 mg per day may not result in any additional benefits from vitamin C (Table 2).

### **Summary**

- Water-soluble vitamins include the vitamin B-complex and vitamin C, and are essential nutrients needed daily by the body in very small quantities.
- The B-complex vitamins can be found in a variety of enriched foods like cereal grains and breads, as well as other foods such as meat, poultry, eggs, fish milk, legumes, and fresh vegetables. Vitamin C can be found in a many fruits and vegetables.
- Overall, in the United States deficiency is rare for B vitamins and vitamin C; with exceptions for alcoholics, those on a low calorie diet, and the elderly.
- Special attention should be paid to folate (folic acid) intake during pregnancy, in order to avoid birth defects.
- Vegans should be conscious of vitamin B12 intake because it is not present in plant foods.
- Some conditions warrant an increase in vitamin C intake, such as exposure to cigarette smoke, environmental stress, growth, and sickness.
- Over consumption of the water-soluble vitamins is generally not a problem in the United States, especially if the nutrients are obtained through food.
- Large amounts of vitamin B-complex and vitamin C supplements and multivitamins are not recommended. Excesses of these vitamins have no known benefit.

**Table 1. Recommended Dietary Intake (RDA) and Adequate Intake (AI) for Water-Soluble Vitamins**

Life Stage Group	Thiamin B1 (mg/d)	Riboflavin B2 (mg/d)	Niacin B3 <sup>1</sup> (mg/d)	Vitamin B6 (mg/d)	Folate (mcg/d)	Vitamin B12 (mcg/d)	Biotin (mcg/d)	Pantothenic Acid (mg/d)	Vitamin C (mg)
<b>Infants<sup>2</sup></b>									
0 - 6mo	0.2*	0.3*	2*	0.1*	65*	0.4*	5*	1.7*	40*
6mo - 12mo	0.3*	0.4*	4*	0.3*	80*	0.5*	6*	1.8*	50*
<b>Children</b>									
1 - 3y	0.5	0.5	6	0.5	150	0.9	8*	2*	15
4 - 8y	0.6	0.6	8	0.6	200	1.2	12*	3*	25
<b>Males</b>									
9 - 13y	0.9	0.9	12	1.0	300	1.8	20*	4*	45
14 - 18y	1.2	1.3	16	1.3	400	2.4	25*	5*	75
19 - 30y	1.2	1.3	16	1.3	400	2.4	30*	5*	90
31 - 50y	1.2	1.3	16	1.3	400	2.4	30*	5*	90
51 - 70y	1.2	1.3	16	1.7	400	2.4	30*	5*	90
>70y	1.2	1.3	16	1.7	400	2.4	30*	5*	90
<b>Females</b>									
9 - 13y	0.9	0.9	12	1.0	300	1.8	20*	4*	45
14 - 18y	1.0	1.0	14	1.2	400	2.4	25*	5*	65
19 - 30y	1.1	1.1	14	1.3	400	2.4	30*	5*	75
31 - 50y	1.1	1.1	14	1.3	400	2.4	30*	5*	75
51 - 70y	1.1	1.1	14	1.5	400	2.4	30*	5*	75
>70y	1.1	1.1	14	1.5	400	2.4	30*	5*	75
<b>Pregnant</b>									
14 - 18y	1.4	1.4	18	1.9	600	2.6	30*	6*	80
19 - 30y	1.4	1.4	18	1.9	600	2.6	30*	6*	85
31 - 50y	1.4	1.4	18	1.9	600	2.6	30*	6*	85
<b>Lactation</b>									
14 - 18y	1.4	1.6	17	2.0	500	2.8	35*	7*	115
19 - 30y	1.4	1.6	17	2.0	500	2.8	35*	7*	120
31 - 50y	1.4	1.6	17	2.0	500	2.8	35*	7*	120

Table 1 is a summarization of the new standards for nutrient recommendations of water-soluble vitamins: The Dietary Reference Intake (DRI). These recommendations meet the average daily nutritional needs of all healthy people. To ensure the needs of all in the population, the DRI usually exceeds the requirements for most people. They do not cover requirements for illness and special health disorders.

RDA and AI values from the 1998 and 2000 DRI reports.

<sup>1</sup> NE=Niacin Equivalents. 1mg of Niacin=60mg of tryptophan; 0-6mo=preformed niacin (not NE).

<sup>2</sup> At 6 months of age, infants may be introduced to solid foods while remaining on formula or breast milk. There may be some overlap in specific nutrient requirements.

(mg=milligrams, mcg=micrograms)

\*AI value

**Table 2. Tolerable Upper Intake Level (UL) for Water-Soluble Vitamins**

Life Stage Group	Thiamin	Riboflavin	Niacin (mg/d)	Vitamin B6 (mg/d)	Folate (mcg/d)	Vitamin B12	Biotin	Pantothenic Acid	Vitamin C (mg/d)
Infants <sup>1</sup> (0 - 12mo)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Children	ND	ND				ND	ND	ND	
1 - 3y			10	30	300				400
4 - 8y			15	40	400				650
Males and Females	ND	ND				ND	ND	ND	
9 - 13y			20	60	600				1200
14 - 18y			30	80	800				1800
19 -> 70y			35	100	1000				2000
Pregnancy and Lactation	ND	ND				ND	ND	ND	
14 - 18y			30	80	800				1800
19 - 50y			35	100	1000				2000

Table 2 is a summarization of the Tolerable Upper Intake Level (UL) for water-soluble vitamins: The Dietary Reference Intake (DRI). The UL is defined as the highest level of daily nutrient intake that is likely to pose no risk of adverse health effects to almost all individuals in the general population. The UL represents total daily intake from food, water, and supplements.

UL values from 1998 and 2000 DRI reports.

<sup>1</sup> At 6 months of age, infants may be introduced to solid foods while remaining on formula or breast milk. There may be some overlap in specific nutrient requirements.

(mg=milligrams, mcg=micrograms)

ND=Not determinable due to lack of data of adverse effects in this age group. Source of intake should be from food only.

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