

Selenium: Dietary Sources and Bioavailability

Selenium, which is rich in animal products, is an essential nutrient for humans (1-3). This trace element functions through selenium-containing proteins, or selenoproteins (1). In the early 1970s, researchers discovered that selenium is an integral constituent of the enzyme, glutathione peroxidase. This selenium-dependent enzyme has antioxidant properties, protecting cellular membranes from oxidative damage (1-3). The amount of selenium needed to maximize the activity of this enzyme has been used to estimate selenium requirements of humans (1).

In addition to its antioxidant properties, selenium appears to be involved in the metabolism of thyroid hormones (1). Investigations also indicate that selenium may reduce the risk of certain types of cancer and heart disease as well as enhance the body's ability to fight infections (1-3).

Selenium deficiency was first observed in animals. In humans, severe selenium deficiency in endemic selenium-poor areas of China has been associated with Keshan disease, a congestive heart disease that occurs almost exclusively in children (1-3). In the United States, selenium deficiency has been identified in individuals receiving long-term total parenteral nutrition (TPN) without selenium (3). Increased intake of selenium corrects the biochemical and clinical impairments of selenium deficiency. Selenium deficiency alone seldom causes overt illness. However, it leads to biochemical changes that predispose to illness associated with other stresses. For example, in selenium-deficient mice, a nonpathogenic strain of coxsackie B3 virus is converted to a pathogenic one that causes myocarditis (4). In contrast, in non-selenium deficient mice, this virus does not cause heart damage.

In Western countries, suboptimal selenium status may occur as a result of a poor diet such as subsistence on vegetables grown in selenium-poor soils. However, in the United States and Canada there is no indication of average intakes of selenium below recommended levels (1). Data from USDA's Continuing Survey of Food Intakes by Individuals (CSFII) 1994-96 (5) indicate that

adults 20 years and older consume 106.7 µg of selenium, or more than twice the amount recommended (1). Although selenium is potentially toxic, such toxicity is rare in the United States and excessive intake of selenium from food is an unlikely cause. The Tolerable Upper Intake Level (UL) for selenium, or the maximum intake below which adverse health effects are unlikely, is 400 µg/day for adults (1).

In 2000, the Food and Nutrition Board of the Institute of Medicine updated dietary recommendations for selenium (Table 1). The selenium Recommended Dietary Allowance (RDA) for both adult men and women is 55 µg/day (1). Dietary recommendations for selenium are also established for infants, children, and pregnant and lactating women (1).

Table 1. Recommended Dietary Allowances (RDAs) for Selenium*

Category (µg/day)	Age	Selenium RDA
Infants	0-6 mo	15**
	7-12 mo	20**
Children	1-3 yr	20
	4-8 yr	30
Males	9-13 yr	40
	14->70 yr	55
Females	9-13 yr	40
	14->70 yr	55
Pregnancy		60
Lactation		70

* Adapted from Institute of Medicine, Food and Nutrition Board (1)

** Adequate Intake

Food Sources of Selenium

The richest dietary sources of selenium are animal foods such as organ and other meats, poultry, seafoods, cereals and grains, followed by dairy products, fruits, and vegetables (2, 6, Table 2). The selenium content of foods is variable and dependent on the amount of selenium available in the soil where animals are raised and plants are grown (1-3). For this reason, the same food

can have more than a tenfold difference in selenium content (1). In several regions of the world (e.g., parts of China, New Zealand) soils are low in selenium (1-3). Fruits and vegetables generally contain small amounts of selenium and drinking water usually makes only a negligible contribution to selenium intake (1).

Animal foods and seafoods generally contain more selenium than do plant foods (7). Consequently, vegetarians, especially those who avoid all animal products and who consume diets consisting of plants grown in low-selenium areas, tend to consume less selenium than individuals who include animal products such as meat in their diets (1, 7).

Table 2. Selenium Content of Selected Foods*

Food	Selenium (μg per 100g edible portion)
<u>Meat</u>	
Beef Top sirloin, separable lean, broiled	32.9
Ground lean, broiled	29.0
Liver, pan-fried	57.0
Lamb Composite, separable lean, cooked	26.1
Pork Loin, separable lean, roasted	35.1
Loin chops, separable lean, broiled	47.3
Veal Composite of trimmed retail cuts, lean, cooked	13.0
<u>Poultry</u>	
Chicken, breast, meat only, roasted	27.6
Turkey, breast, without skin, roasted	32.1
<u>Seafood</u>	
Tuna, white meat canned in water	65.7
Salmon, sockeye, cooked	37.8
<u>Cereals, Grains, Pasta</u>	
Life	23.6
Cream of wheat, instant, cooked	11.4
Rice, white, cooked	7.5
Noodles, egg, cooked	21.7
Bread, wheat	30.9
<u>Dairy and Egg Products</u>	
Cheese, Cheddar	13.9
Milk, fluid, 2% reduced fat	2.2
Yogurt, lowfat, plain	3.3
Egg, whole	30.8
<u>Fruits and Vegetables</u>	
Apples, raw	0.3
Bananas, raw	1.1
Oranges, raw	0.5
Beans, snap	0.4
Broccoli, cooked or frozen	1.9
Mushrooms, raw	12.3
Potatoes, baked	0.8

* Adapted from U.S. Department of Agriculture, Agriculture Research Service, USDA Nutrient Database for Standard Reference (6).

When the selenium content of a 3-ounce serving of cooked lean beef sirloin is compared to the RDAs, beef contributes 50.7% of the selenium RDA for adults (1, 6, Table 3). Similar size servings of other meats, poultry and seafood also make a substantial contribution to the amount of dietary selenium recommended (Table 3).

Table 3. Contribution of 3 oz. (85g) of Cooked Meat, Poultry, or Seafood to the RDA for Selenium (1, 6)

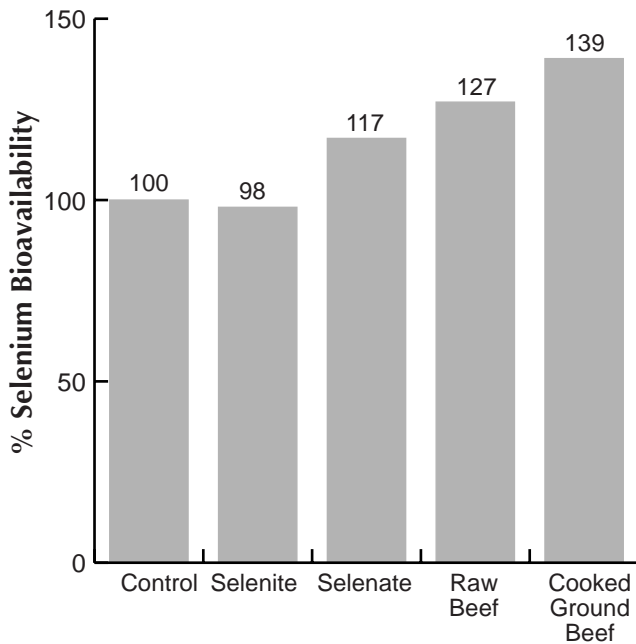
Food	μg Se	% RDA Adults 55 $\mu\text{g}/\text{d}$
Beef, top sirloin, lean	27.9	50.7
Beef liver, pan-fried	48.5	88.2
Pork, loin, lean, roasted	29.8	54.2
Chicken, breast, roasted	23.5	42.7
Turkey, breast, roasted	27.2	49.6
Shrimp, cooked	33.7	61.3
Cod, Atlantic, cooked	32.0	58.2
Tuna, yellowfin, cooked	39.8	72.4

Bioavailability of Selenium

The selenium *content* of foods does not necessarily represent the amount actually absorbed and utilized by the body. The *bioavailability* of selenium may differ according to factors such as the chemical form, food source, composition of the total diet, and the nutritional status of the individual (7). In general, the major forms of selenium in the diet are highly bioavailable (1). Although it is stated that about 80% of selenium from mixed diets is absorbed by the body (7), relatively little is known about factors influencing the bioavailability of this nutrient.

One investigation examined the relative bioavailability of selenium, as determined by liver glutathione peroxidase activity, from raw and cooked ground beef in selenium-deficient laboratory rats (8). Selenium bioavailability was highest for cooked ground beef, followed in decreasing order by raw beef, selenate, selenite, and the torula yeast basal diet (Figure 1). Ground beef not only is an excellent source of dietary selenium, but the selenium is highly bioavailable (8).

Figure 1. Selenium Bioavailability from Raw and Cooked Beef*



* Adapted from Shi, B. et al. (8).

Summary

Although most Americans readily meet the RDAs for selenium, a deficiency of this essential nutrient can occur in some populations living in areas or countries with selenium-poor soils. Selenium deficiency can be prevented by the judicious selection of foods. Meats, seafood, poultry, cereals and grains, and dairy products are good sources of selenium. Fruits and vegetables generally contain small amounts of selenium and the

selenium in drinking water is negligible. The selenium content of foods can vary according to the selenium content of the soil in which the food is grown. Relatively little information is available regarding the bioavailability of selenium from different foods. However, findings indicate that beef not only is a good source of selenium, but the selenium is highly bioavailable. To meet selenium as well as other nutrient needs, a nutritionally balanced diet containing a variety of foods from the basic food groups consumed in moderation is recommended.

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