NUTRITIONAL ASPECTS OF SELENIUM (SE)

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Summary. The aim of this study is to present the current scientific achievements in the knowledge on selenium in order to enable the focusing on the specific aspects of the issue to the nutrition dimension. The cumulation of more specific data is important for reaching greater effectiveness of food and nutrition implementation in prevention of selenium deficiencies. Information is presented on the biological role of selenium, effects of selenium deficiency, selenium nutritional forms, Se content in various foods, recommendations for daily Se intake, Se intake of the population from some European countries and on selenium safety. The analysis of available current scientific evidence reveals numerous disputable issues and provides sufficient data for implementation of an adequate preventive policy complying with the specifics of the population groups and their geographic origin.

Key words: nutrition, selenium

INTRODUCTION

The development of selenium knowledge has a long and very interesting history. The discovery of this trace element was realized in 1817 by the Swedish chemist Berzelius. He named the new element “selenium” after the Greek word “selene”, which means moon [2, 4].

The primary investigations on the biological role of selenium recognized Se as a highly toxic element with hepatotoxic and carcinogenic activity. This consideration existed until 1957. At that time, K. Schwartz, a German physician, indicated that compounds containing Se are essential nutrients for experimental animals [12]. To scientists’ great surprise, in 1969 D. Frost succeeded to challenge the controversial evidence of Se-carcinogenicity, suggesting that Se might prevent, rather than cause cancer [4]. This fact provoked the scientific interest and in 1973 essentiality of Se for human beings was shown as well [1]. A comprehensive clinical study, conducted by Larry Clark et al supported the protective effect of selenium against cancer. The findings assisted to challenge the contemporary conceptions about nutritional essentiality [3].

The endemic Se-deficiency in humans has been associated with two diseases: juvenile cardiomyopathy (Ke-shan disease) and chondrodystrophy (Kaschin-Beck disease). Both of them occur in rural regions of China and Russia, and both have shown dramatic reduction in the incidence after prophylactic treatment with selenium (Combs, 2001). The essentiality of Se for production of thyroid hormone is a factor for prevalence of the T-deficiency diseases, goiter and myxedematous cretinism among populations with low Se status.

The recent interest in selenium has resulted from many scientific data, showing that low or suboptimal levels of Se-intake are associated with a wide variety of human diseases (cancer, heart diseases, iodine-deficiency diseases, various neurodegenerative diseases, associated with accumulation of insoluble proteins and others) [1, 6, 7, 8, 9]. Considerable evidence points to the importance of an adequate supply of selenium to maintaining health. Several epidemiological and preclinical studies have enhanced the belief that higher intakes of selenium might increase the preventive effects [8]. In response to the new scientific achievement, it is necessary to present more information about nutritional aspects of selenium.

The purpose of our study was to present the current scientific information, concerning some nutritional aspects of selenium including: nutritional forms of selenium, dietary sources and safety intake.

NUTRITIONAL FORMS OF SELENIUM

The biological activity of selenium has been reported to be associated primarily with its antioxidant activity through the selenoenzyme glutathione peroxidase (EC 1.11.1.9; GSH-PX), but also through other selenoenzymes and selenoproteins, recently discovered. Through the enzymes types I and II iodothyronine deiodinases Se is also involved in the thyroid metabolism. Selenium status has been demonstrated to be a strong predictor of a variety of disease progression and mortality [6, 10, 15].

The major forms of Se in foods are selenoamino acids – selenomethionine, selenocysteine and selenocystine. Little, or none can be found as methylated Se, selenoamino acids, in particular selenomethionine, have higher bioavailability in comparison with inorganic species. This amino acid is the most appropriate supplemental form of selenium. Selenomethionine replaces methionine in plant proteins and this is the major dietary form of selenium for animals and humans. Selenomethionine is directly metabolized and incorporated primarily into the proteins of erythrocytes, liver, pancreas, skeletal muscles, the kidneys, stomach and gastrointestinal mucosa [11]. The dietary Se intake affects the blood Se level. Selenomethionine provides all forms of selenium required for selenoproteine biosynthesis. The selenomethionine, which is not used for protein synthesis is converted through transsulfuration pathway to selenocysteine, or through degradation from f-lyase to methylselenol and homoserine [1]. Selenoamino acids have higher bioavailability than the inorganic Se-species. Selenate is reduced to selenite by a number of reactions. Selenium from selenoamino acids and selenite can be converted to selenides and subsequently to mono-, di- and tri- methylated forms. The trimethyl Se is excreted with urine, the dimethyl form is exhaled and the monomethylated one is released by metabolism of selenomethionine [1, 14]. Those selenium derivatives may provide useful markers of Se-status. Data on selenium intakes in some European countries are presented in Table 1.

Table 1. Mean selenium intakes in European countries (after ERNA 2004)

COUNTRY	SELENIUM INTAKES (mg/day)
Belgium	28 - 61
Denmark	41 - 57
Finland	100 - 110
France	29 - 43
Norway	28 - 89
Sweden	24 - 35
UK	63

DIETARY SOURCES OF SELENIUM

The dominant food sources of Se are cereals, fish and meats. Vegetables and fruits are low in Se and provide only small amounts in human diets. Dairy products and eggs are also pure sources of Se. The content of selenium in plant food depends on the selenium content of the soil. The intake of selenium from soil is influenced by a number of various parameters (PH, moisture, geographical conditions). Many regions in the world are notable for having very low amount of Se in the soil and, respectively, in their food system. Such regions in Europe are Denmark, Finland. In contrast some parts of Ireland are seleniferous. The plants and microorganisms take up selenium into their tissue proteins. The supply of selenium to humans through food is an effective preventive practice against selenium deficiencies. Selenium is added to specific foodstuffs for particular nutritional uses (formulae milks, food supplements and drinks) in accordance with EU legislation [5, 13]. The more commonly found form of selenium are multivitamin and mineral supplements or in combination with antioxidant products. The availability of soil Se to crops can be modified by different soil management procedures. The absorptions and subsequent metabolism of selenium are related to its chemical form. The bioavailability of this trace element depends on its absorbability and mucosal transfer into the systemic circulation and utilization within the body. Some dietary factors can enhance (thiols, vit. C), or inhibit (methionine, phosphorus, heavy metals) Se-bioavailability [7, 10]. Bioavailability is defined as the proportion of total Se-content in food, meal or diet that is utilized in the gastrointestinal lumen (absorbability). The bioavailability is not a property of food per se, but is the response of individual to the food and represents an integration of various food ingredients. Thus it is very important to know the exact Se-quantity in foods, in order to compile the human diet. Table 2 presents selected food sources of selenium as reported by different authors.

Table 2. Selected food sources of selenium

Foods	Selenium content Mg/100g	Authors
1. Nuts, brazilnuts, dried	1917.11	USDA National Nutrient Database for Standard Reference, release 18, Last updated, 12 October 2009
2. Nuts, mixt nuts, oil roasted, with salt added	421.16	
3. Fish, tuna, canned in water	80.35	
4. Wheat flour, whole-grain	70.67	
5. Chicken, broilers or fryers	59.59	
6. Oat bran, raw	45.21	
7. Pork fresh	44.35	
8. Beef, cured, canned	42.92	
9. Spaghetti, whole-wheat, cooked	25.93	
10. Milk, canned, con-densed	14.80	Barclay, M. et al. Selenium content of a Range of UK Foods Y of Food Comp. and Anal. 8, 308-381, (1995)
11. Milk (whole) Cheese	1.5	
12. Brie	10	
13. Camembert	11	
14. Cheddar	10	
15. Edam	10	
16. Gouda	11	
17. Bread (brown)	4.8	
18. Bread (White)	4.4	
19. Rise (brown)	11	
20. Barley	10	
21. Potatoes	1.6	
22. Beans	10	
23. Selected fruits	10	
24. Coffee (instant)	12	
25. Chocolate dark	10	

SAFETY OF SE-INTAKE

Selenosis is a condition, associated with excessive intake of selenium. The symptoms of this pathology are hair or nail loss, mottled teeth and skin lave such symptoms after reducing the intake down to 850 mg/day. The Food and Nutrition Board set a NOAEL (no observed adverse effect level) of 800 mg/day, and the SCF (Scientific Committee on Food) – of 850 mg/day. On this basis, there was determined the Tolerable Upper Intake Level (UL) of 300 mg/day and the FNB set an UL of 400 mg/day [5].

Selenium toxicity is rare. It can be associated with some industrial accidents and manufacturing error, which can lead to highly excessive doses of selenium. It is recommended to perform Se-nutritional assessment to reveal the quantity from diet and especially from food supplements.

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