DOES BIOAVAILABLE ARSENIC AFFECT NUTRITIONAL SELENIUM?: A BRIEF REVIEW of Se NUTRITION

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Identification of the metabolite seleno-bis(*S*-glutathionyl) arsinium ion (Gailer, 2000), which allows mutual excretion of arsenic (As) and selenium (Se), raises a question: What is the physiological effect of bioavailable As if dietary Se is low, and possibly deficient? This review describes basic functions of Se-metabolites and some effects of nutritional Se-deficiencies. It suggests that physiological depletion of low dietary Se by bioavailable As may exacerbate the etiologies of several human diseases and, perhaps, those of wildlife. Descriptions of the geochemistry of either Se or As bioavailability are detailed elsewhere.

Essential Se is critical as the catalytic component of glutathione peroxidase (Se-GPX) (Rotruck, 1973), a physiological antioxidant, and cellular Se-GPX is ubiquitous in prokaryotes as well as eukaryotes (Burk, 1993), including humans. Concentrations of different selenoproteins (SP), for example cSe-GPX, depend on overall Se nutrition (Patching, 1999); Se is bioavailable as inorganic Se(IV) or Se(VI), from drinking water, or as Se-amino acids selenomethionine (Se-Met) and selenocysteine (Se-Cys[1]), found in many foods of plant or animal origin (Combs, 1986). Se metabolizes to essential Se-Cys from both Se(IV) and Se-Met, and less so from Se(VI). Se-Cys is the predominant active component of the various SPs (Figure 1), and it is critical (Allen, 1999) to nutrition[2]. Nutritional Se-deficiencies can become manifest in any phase throughout the life cycle (Surai, 2000).

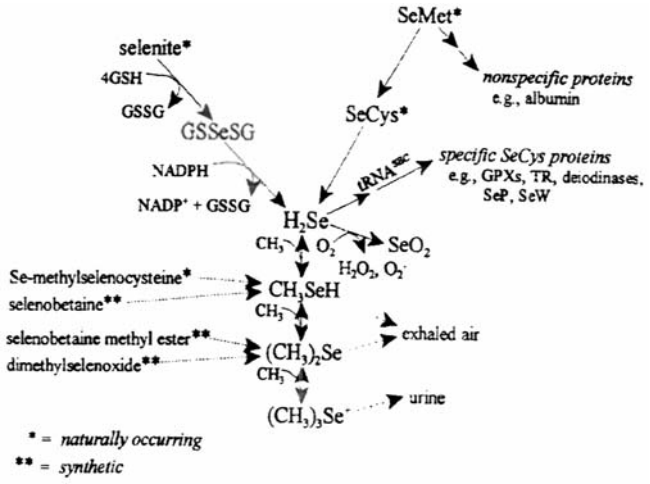

Figure 1. Metabolism of selenium. CH_3SeH, methylselenol; $(CH_3)_2SE$, dimethylselenide; $(CH_3)_3Se^+$, trimethylselonium; H_2Se, hydrogen selenide; SeO_2, selenium dioxide; tRNA, transfer RNA. Specific SeCys proteins include GPXs, several glutathione peroxidases; TR, thioredoxin reductase; deiodinases, including iodothyronine 5'-deiodinases; SeP, selenoprotein P; SeW selenoprotein W. (from Combs, 1998)

Physiological diversity of SPs (Holben, 1999) occurs as antioxidants, predominantly through different Se-GPXs (cellular Se-GPXs, plasma Se-GPX, phospholipid hydroperoxide Se-GPX, and gastrointestinal Se-GPX), thioredoxin reductase, and several selenoproteins (e.g., plasma Se-P, muscle Se-W, and placental Se-22). Other SPs include selenophosphate synthetase; types 1, 2, and 3 iodothyronine deiodinases, which form and regulate

[1] The biological significance of selenocysteine (Sec) is recognized as the 21st essential amino acid.

[2] The Food and Drug Administration's Recommended Daily Allowance for Se for adults ranges from 55 to 70 ug/day (NIH,2000), and in 1992, EPA revised its Maximum Contaminant Level for Se from 10 ug/l to 50 ug/l (EPA, 1996). The EPA new standard for arsenic in drinking water reduces the maximum level allowed from 50 parts per billion (ppb) to 10 ppb (EPA, 2001).

thyroid hormone; and "a protein in the sperm mitochondrial capsule,. . .vital to the integrity of the sperm flagella (Holben, 1999)". Thus, various SPs reduce oxidative stress and regulate thyroidal growth and development, cell growth (Ozolins, 1996; Holben, 1999), including tumorigenesis, and immune system integrity (Patching, 1999).

The spectrum of nutritional Se is fairly narrow (Figure 2), but estimated daily intake by humans ranges from 7 to 4990 ug (Combs, 1986). Toxicities occur with elevated Se intake (Combs, 1986; Olson, 1986; Heinz, 1996; Lemly, 1996), and malnutrition with deficient Se intake. Initial recognized symptoms of Se-deficiencies were cardiomyopathies (Keshan disease) and osteoarthropathies (Kachin-Beck disease), both occurring in areas of low Se bioavailability in China (Combs, 1986). Other maladies associated with low nutritional Se include impairment of the immune system by infection by HIV (human immunodeficiency virus) (Cowgill, 1997; Baum, 2000; Taylor, 2000) and various TESs (transmissible spongioform encephalopathies) (Purdey, 2000), such as found in cattle (BovineSE) and in humans (Creuzfeldt-Jacob Disease). Se deficiency impairs spermatogenesis (Holben, 1999). As a preventive, elevated nutritional Se is reputed to have anticarcinogenic properties against several types of cancer (Combs, 1998).

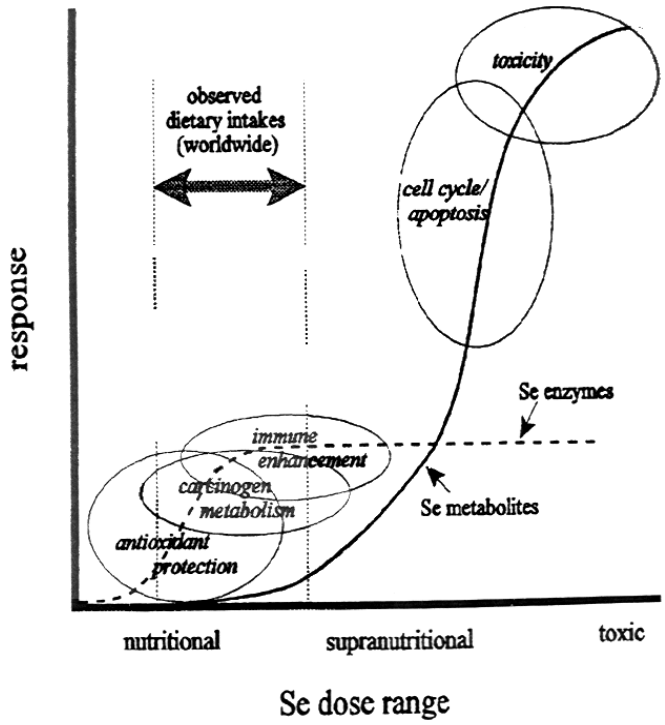

Figure 2. Two-stage model for the roles of Se in cancer prevention (Combs, 1998), adopted here to depict general Se nutrition dosage.

Correlations between the geographic distribution of the range of bioavailable Se and health are increasingly cited (among them, Combs, 1986; Cser, 2000; Nordberg; 2000; Simonffy, 2000) as information about the effects of nutritional and dietary Se become available. This review questions whether geographically low levels of dietary Se are challenged by the presence of bioavailable As.

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