INVESTIGATION OF THE APPEARANCE OF SUPPLEMENTAL ENRICHED Se-76 USING THE HUMAN NAIL AS A DIETARY MONITOR


*Missouri University Research Reactor Center, Columbia, MO 65211 (USA)
**Animal Science, Michigan State University, East Lansing, MI 48824 (USA)
***Food Science and Human Nutrition, University of Missouri, Columbia, MO 65211 (USA)

The principal objective of this study was to determine if the use of a stable enriched tracer of Se-76 could be used to determine the delay time between a dietary intake of selenium and its appearance in fingernails and toenails. Selenium is an essential trace element in human nutrition. It has been studied at the Missouri University Research Reactor (MURR) for the past 15 years using an Instrumental Neutron Activation Analysis (INAA) technique. The principal route of human exposure to selenium is through the diet. Selenium concentrations of nails, blood, hair, and urine have been used as indicators of dietary selenium intake. In this study, a cohort consisting of seven men and five women ingested three selenium supplements of 150 μg each over a three day period. The selenium was enriched in Se-76 (96.48%) and ingested as selenite in orange juice following an overnight fast. Fingernails and toenails were collected prior to the selenium supplementation and for several months afterward to be used as biochemical indicators. The peak 76Se concentration in the fingernails and toenails occurred at 19-23 and 16-32 weeks after supplementation, respectively.

Selenium (Se) is an essential trace element in human nutrition. It is present at the active site of glutathione peroxidase (GSH-Px). GSH-Px functions as a protective enzyme and is important in the detoxification of hydrogen peroxide, organic hydroperoxides, or lipid peroxides. Selenium in the reduced form of GSH-Px is present as selenocysteine. The moiety is incorporated into the peptide backbone of the enzyme and is essential for its activity. Selenium is regarded as being important for metabolic protection from oxidative stress, especially in diseases of the heart muscle and may also be important in protection against carcinogenic substances. Se deficiency results in a decrease in cellular and plasma GSH-Px activity and also in a decrease of erythrocyte GSH-Px protein.

The mechanism of action of GSH-Px requires the presence of selenocysteine at the active site and therefore Se status controls GSH-Px activity. Modulation of GSH-Px mRNA levels could occur transcriptionally or posttranscriptionally. Human studies have indicated that each individual might have an optimal enzyme level. The enzyme level was suggested to be a balance between Se intake and other factors which influence GSH-Px activity, such as age, ethnic background, sex, physical activity, oxidant stress, iron deficiency anemia, and essential fatty acid deficiency.

Selenium has a protective effect against oxidative damage by reducing the concentration of free radicals through the production of GSH-Px which enzymatically protects cell membranes by the chemical reduction of free radicals and peroxides. Selenium and vitamin E act in concert to reduce the concentration of free radicals. Vitamin E prevents formation of lipid peroxides by removing free radicals before they initiate lipid peroxidation; Se reduces already formed hydroperoxides to less reactive alcohols. These two antioxidants are able to...
suppress chemically induced and spontaneous carcinogenesis in animals. An inverse correlation has been observed between the dietary intake of these antioxidants and the incidence of breast and colon carcinoma. Selenium and vitamin E appear to have overlapping complementary roles in the protection of cells. The deficiency of either Se or vitamin E in animals causes degenerative lesions in tissues. The effects of Se and vitamin E deficiency are thought to result from loss of membrane integrity which leads to cell death. There are interrelationships and synergistic effects between vitamin E and Se. Both vitamin E and Se-dependent GSH-Px are able to decrease the production of lipid peroxidation products. Vitamin E acts as a chain-breaking antioxidant, and is the main protector against in vivo lipid peroxidation. Dietary Se, through its involvement in the synthesis of GSH-Px, functions in a secondary antioxygenic role as a hydroperoxide reducer.

More than 12 selenoproteins have been identified in mammals, but few have been studied in detail. Type I iodothyronine 5'-deiodinase is found primarily in liver, thyroid, and kidney. Its function is to convert the inactive thyroid hormone thyroxine (T4) into the active T3 form, 3':5,3-tri-iodothyronine. The gene which codes for type I iodothyronine 5'-deiodinase contains the codon which specifies selenocysteine insertion into the protein. Selenoprotein-P was purified by YANG et al. They discovered that selenoprotein-P was a single 57-kd glycoprotein. The function of selenoprotein-P is unknown, but it is thought that this protein serves a selenium transport function or is involved in redox reactions. There are 10 sites for selenocysteine in the amino acid sequence of selenoprotein-P.

It has been suggested that the brain has a high priority for Se when the supply of Se is limited. Unpublished experiments have demonstrated that rat brain compared to other tissues shows high priority for Se when the supply is limited. Experiments were conducted with rats fed diets adequate or low in Se for 5 weeks, injected with high specific activity 75Se-selenite, and killed at various time intervals. Five brain regions and liver were analyzed for total Se and 75Se retention. The brain did not show large decreases in Se concentration during dietary Se deficiency and Se was redistributed from other tissues to the brain to maintain the Se level in the brain. These results were demonstrated by the uptake of 75Se in the brain following injection of 75Se-selenite. The concentration of 75Se in the brain increased as 75Se concentrations in the liver decreased. 75Se uptake by the brain may be associated with specific transport mechanisms and may indicate a relatively long turnover for selenoproteins in brain.

The functions of Se in the brain are not known, but may be related to protecting the brain against lipid peroxidation. GSH-Px and selenoprotein-P may have roles in protecting membranes against lipid peroxidation by reducing hydroperoxides. The brain is susceptible to lipid peroxidation. Se-dependent enzymes may be particularly important in the brain to protect against damaging effects of free radicals. GSH-Px activity in the brain is at lower levels than in Se-adequate liver. This indicates an importance for selenoproteins besides GSH-Px in the brain. Selenoprotein-P is thought to have a redox function.

The principal route of human exposure to Se is through the diet. The uneven distribution of Se in soils reflects the content of the rocks from which the soils were formed; this results in regions of very low and very high natural Se levels. Health effects have been reported at both high and low extremes of Se intake. Low Se status has been associated with Keshan Disease, a cardiomyopathy in regions of China where Se levels are extremely low. Lower selenium levels have an association with an increased risk of cardiovascular disease. Se deficiency is also a contributing cause of Kaschin-Beck Disease, an endemic osteoarthropathy in China. Low dietary Se is linked with increased cancer risks. Symptoms allegedly caused by a seleniferous diet are defects in fingernails, toenails, and hair and an intoxication is characterized by nail deformities and loss of nails and hair.