



SELEN-Biofrid - a Food Supplement containing L-Selenomethionine

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Selenium: History and Occurrence

Selenium, Se, was discovered by Jöns Jakob Berzelius in 1817, is numbered 34 in the Period Table, and is found in the same main group of the Periodic Table as Oxygen, Sulphur and Tellurium. It was found along with the last two of these in a copper mine. Berzelius called it after the Greek goddess of the moon, Selene, so as to establish an opposite to Tellurium, which had been called after the earth. Selenium is found in several modified forms; the most stable is the grey, metallic one. Occasionally it is found pure in small quantities, or it may likewise be found rarely in selenic minerals such as Clausthalite and Naumannite.

It is mostly found in the form of metallic selenides, in the company of sulphurous metallic ores of copper, lead, zinc, gold and iron. When these ores are smelted, selenium is found in the ash as selenium dioxide, or, in the subsequent production of sulphuric acid, it occurs as a selenic acid. The element selenium can be extracted from selenium dioxide with the aid of sulphur dioxide.

In the Plant kingdom selenium occurs particularly in varieties of astragalus (n.o. Leguminosæ) and in garlic, whereas other common kinds of vegetable and fruit tend to be low in selenium. This is particularly applicable when the soil has been treated with sulphur-containing fertilizers. In most vases the plants themselves do not require any selenium and only absorb it when there is a lack

of sulphur. Only then can an animal organism utilise it. It is abundantly present in fish, pork, eggs and poultry meat.

Properties of Selenium

Just like sulphur, selenium also occurs in a variety of forms. A distinction is made between red and black selenium, which convert to the grey "metallic" selenium at temperatures of over 80°. This behaves like a semi-metal. This grey form is the most stable modification. If heated to above 220°C, the element melts, forming a black liquid. If this is heated further, it changes into a yellow selenium vapour. If this vapour comes into contact with cooler surfaces, then metallic-grey crystalline needles are formed. The electrical conductivity of selenium changes on exposure to light, and it also exhibits photovoltaic effects. This aspect of the element's behaviour explains its use in photo-electric cells (light meters, solar cells), rectifiers and photocopiers. It is also used for colouring glass (red and green). There are six isotopes of selenium.

Chemical compounds of Selenium and their Bio-availability

Selenium occurs in inorganic and organic forms.

1. Inorganic selenium compounds: Here we are dealing with compounds of selenium with e.g. the earth alkali sodium as Sodium selenite (salt of seleneous acid), sodium selenide (binary metallic compound, which may also be understood as a salt of hydroselenic acid, 'R-Se-R'),

sodium selenate (salt of selenic acid). These salts have a bio-availability for humans of c. 50-60%. They are absorbed in the upper part of the small intestine, taken up by the erythrocytes and there reduced enzymatically to hydrogen selenide. This again serves as a specific form of selenium for incorporation into so-called selenoproteins and excretion in the form of dimethylselenide. If inorganic selenium compounds are supplemented, particular care should be taken that they are given independently from other powerful anti-oxidants, such as Vitamin C. This is because inorganic selenium compounds are broken down by Vitamin C, thus being rendered inactive. There should be an interval of at least an hour between taking them.

2. Organic selenium compounds: These include selenomethionine and selenocysteine in particular, the latter also being referred to as the 21st biogenic amino-acid. The organic compounds have a better bio-availability than the inorganic ones. This is particularly true of selenomethionine, which is consumed with many food-stuffs and incorporated into the body instead of methionine. It may therefore be regarded as a special selenium store for the organism.

Significance of selenium in the organism (of mammals)

In 1957 Schwarz discovered the value of selenium for the human body. Until then it had only been



considered poisonous, which related back to Berzelius' experiences, when he was handling the fatally poisonous hydrogen selenide vapour. However, prior to that it had been used with astonishing success in treating inoperable tumours. In veterinary medicine it had been used since the 1930s for treating muscular diseases of lambs (white muscle disease) and of pigs ("banana disease"). But it was not until the years 1974-1979 that selenium's great essential importance to human beings became clear, when in China classic selenium deficiency diseases (Keshan disease and Kashin-Beck disease) were discovered on soil that was extremely low in selenium.

Keshan disease refers to a dilatative cardiomyopathy in humans, in which the heart muscle is extremely enlarged. Those particularly affected are children and young people. To some extent it resembles Mulberry heart disease in pigs, in which there is likewise severe hypertrophy of the left side and dilatation of the right side of the heart, with the pericardium being full to bursting. The whole heart is covered with sub-epicardial hæmorrhages like pin-pricks, which gave the disease its name. (Prophylaxis for mulberry heart disease consists of dosing with Vitamin E and selenium.) In the case of Kashin-Beck disease, likewise discovered in areas of Asia and Russia, the joints suffer inflammatory degeneration on account of a selenium deficiency.

The human body contains 10-30 mg of selenium. It is incorporated in

various proteins - selenoproteins - with specific metabolic functions. So far we know of 35 such selenoproteins with very varied significance, 14 of which can already be described in some detail. I will briefly mention the most important ones below:

a. Glutathione peroxidase (GSH-Px, or GPx) is regarded as the most significant of the selenoproteins. It exists in four different forms (GSH-Px-1 to GSH-Px-4). They are given a nomenclature which depends on their main sphere of action and, for the sake of simplicity, this is replaced by numbers. All Glutathione peroxidases have an anti-oxidative action; they break down hydroperoxides of an exogenous and an endogenous nature. In this, selenium functions in the active centre of Glutathione peroxidase (GPx) as a catalyst for glutathione that has been broken down. The most important is GSH-Px-1: it prevents peroxides from attacking and destabilising membranes and cell walls in cytosol and mitochondria. GSH-Px inhibits the formation of inflammatory prostaglandins and leucotrienes which are formed when arachidonic acid is broken down. This is the basis for its positive action in chronic inflammations, especially rheumatism. The highest activity of GSH-Px is found in the erythrocytes and thrombocytes, where it prevents hæmolysis and aggregation of thrombocytes, and also in the liver, the pancreas

and the lenses of the eyes. (Since different levels of selenium concentration are required for the various glutathione peroxidases to attain their maximum action, the researchers' indications for supplementation are variable.)

b. Thioredoxin reductase (TrxR or TRR) is important for cell growth. This enzyme contains selenocysteine and, together with glutathione reductase is of central importance for cellular thiol metabolism. Not only does it serve for anti-oxidative defence, but it also regulates redox processes within and outwith the cells. In the case of some tumours a large amount of thioredoxin is formed, and this inhibits apoptosis, promotes the growth of human cancer cells and is said to be implicated in resistance to cytostatics. In this case TrxR, with its selenium content, is of particular importance. In a variety of mammalian organisms the thioredoxin and glutathione systems work in parallel and complement each other. However, they can also substitute for each other.

c. Iodothyronine-5'-deiodinases (ID-I to III) catalyse thyroid hormone and, inter alia, they are responsible for the conversion of T4 into T3. They act within a variety of tissues with special hypofunctions, e.g. in liver, kidneys, thyroid and musculature of skeleton and heart as ID-I; in brain and pituitary with increasing

frequency as ID-II, which is responsible for maintaining a constant level of T3 in the CNS; in the placenta, foetal liver and glia cells as ID-III, which in the foetus converts T4 and T3 into an inactive form and also de-activates the maternal T4, so as to protect the child's CNS from an over-supply of T4. The enzymes which affect the thyroid hormones are also referred to as deiodases.

- d. Selenoprotein P (SeP) acts within the plasma as an important transport protein for selenium to the cells and contains 8-10 selenium atoms. Its antioxidative protection particularly benefits the endothelial cells of the liver.
- e. Selenoprotein W was found in the musculature; its significance is as yet unclear. The skeletal musculature is the greatest selenium store in the body.
- f. Selenophosphate synthetase (SeiD2) catalyses the synthesis of monoselenophosphate, which is a precursor of selenocysteine.

With regard to the significance of selenium, it may generally be said that, bound to proteins in the form of GSH-Px, SeP and TrxR, it is involved in maintaining the physiological redox potential in the body. Above all this refers to the detoxification of aggressive metabolic products which are toxic to the cells. Thus selenium has a strongly protective action in many degenerative diseases involving wear and tear and so-called

lifestyle diseases. This detoxifying function also extends to heavy metals such as mercury, cadmium and lead. On the one hand the radicals caused by heavy metals are captured, and on the other hand the heavy metals themselves are bound as selenides, so that they surrender a large proportion of their toxicity on account of the stability of the bond. The action of selenium is supported by other anti-oxidants such as Vitamin E, whose action it surpasses by about 100 times, Vitamin C, riboflavin and anthocyanins.

The immune system relies on an adequate supply of selenium, since it stimulates lymphocyte proliferation. It promotes interferon- γ -synthesis and activates the cytotoxic T-cells and the natural killer cells.

Food sources of Selenium and optimum Supply

The main source of selenium is animal and vegetable protein. However, it must be borne in mind that the plants' and animals' selenium uptake is dependent on the amount of selenium in the soil. Compared with Canada, for instance, Germany, Denmark, New Zealand and Eastern Finland are "selenium-deficient countries". On the other hand, animals store selenium in their bodies, especially if they are given selenium supplementation in their feed. That is generally the case with pigs and poultry, so that their meat and products from it, just like fish (herring and tuna) constitute a good source of selenium for humans, since they

accumulate the amounts of selenium that they consume with their food. Brewer's yeast, various nuts (especially coconut), sesame seeds, pistachios, wheatgerm, clover, brown rice, garlic, onions, broccoli, other brassicas and tomatoes are particularly rich in selenium, if they are grown on the right soil. It should be borne in mind that selenium compounds are particularly volatile, and that selenium is easily lost from food in cooking.

In Germany it has been ascertained that the average daily selenium intake is 47 μg for men and 38 μg for women, 67% of which is via animal protein. The German Nutrition Society (Deutsche Gesellschaft für Ernährung) proposes a daily selenium intake of 20-100 μg . By contrast, the National Research Council of the USA recommends a daily selenium intake of 1 μg selenium per kg of body weight. The citizens of Germany do not attain that level; on average they consume 0.67 μg selenium per kg of body weight, although it would be desirable to achieve the level to which America aspires. Admittedly Germany is not a country with pronounced endemic deficiency symptoms, but selenium deficiency may occur in vegans, or in cases of special need. To maintain our health at optimum level, it is suggested that the daily selenium intake should be 70-200 μg . Because the difference between healthiness and toxicity is so slight in selenium intake, a daily level of 300 μg should not be exceeded in the long term. However, there are indica-



tions that, for healthy people, 500 µg a day is not toxic. Only when the level reaches 900 µg is the cost of over-supply reckoned in terms of hair loss, changes in skin and nails, fatigue, headaches and neuropathies. Following acute overdosing a strong odour and taste of garlic occurs, because the selenium is excreted as the metabolic product dimethyl selenide. There are also abdominal pain and nausea. In some regions of South America so-called selenosis occurs; here because of the state of the soil there is a long-term daily consumption of 2-4 mg selenium.

Elevated Selenium Requirement

Factors resulting in an elevated requirement for selenium include: alcoholism; certain drugs, such as diuretics and laxatives; chemotherapy and radiotherapy; chronic diseases such as AIDS, hepatitis, cancer, coronary infarction, rheumatism; burns; septicaemia; acute pancreatitis; dietary indiscretions and assimilation disorders; kidney disease; oxidative and nitrosative stress, resulting in the occurrence of numerous free radicals or the consumption of heavy metals (smoking, poisoning); Vitamin B6 deficiency.

Selenium deficiency can find expression in the following ways:

- susceptibility to infections
- stunted growth
- myopathies: functional disorders and weakness, calcium deposits in the muscle fibres
- diseases of the heart, especially endothelial disorders, infarction,

myocardial necrosis, heart muscle diseases (Keshan disease, mulberry heart)

- hæmolysis and increased production of methæmoglobin
- elevated cholesterol levels
- low levels of coenzyme Q
- disorders of thyroid hormone metabolism, shift in ration of T3 to T4, cretinism
- increased sensitivity to heavy metals, particularly Cd and Hg
- necrosis of the liver
- cataracts
- reduced resistance to pre-cancerous states (cervix, large intestine, stomach, liver and prostate cancers)
- osteoarthropathies (Kashin-Beck disease, big joint disease)
- changes in skin and nails (ridged nails)

Further therapeutic considerations regarding Selenium

Selenium plays an important part in the Complementary treatment of cancer, because most cancer patients have depressed selenium levels and exhibit reduced GSH-Px activity. Experience shows that this deteriorates still further when chemotherapy and radiotherapy are employed. Selenium can be used to palliate the side-effects, and - as already described above - it can also considerably enhance their effectiveness. As regards secondary lymphoedema, especially in women who have had a mastectomy, and skin changes resulting from such measures, which can also result in nycturia and depressive moods, marked improvements can be achieved by giving selenium.

Outstanding results have been achieved with selenium in heart attack prevention (Finland!) and in acute pancreatitis (Eastern Germany). Comprehensive studies exist regarding both diseases. In Finland, the government has been carrying out legally enforced selenium enrichment of cereals since 1984, because vast numbers of Finns had been suffering heart attacks owing to the composition of the soil. To achieve protection from cardiac infarction the selenium level in the plasma must amount to 60 µg per litre.

In the case of "big joint disease", discovered in China and affecting mainly children, dosing with selenium enabled a reduction in its occurrence from 42% to 4%. These facts should certainly impact on any considerations as to the treatment of rheumatic diseases and of other chronic inflammations. In many cases of muscular diseases selenium and Vitamin E should be given simultaneously. Supplementation with one of these admittedly gives relief in certain disorders, but optimum success is only achieved when both substances are given.

Research groups are investigating the significance of free radicals in brain diseases such as Alzheimer's, Parkinson's and in amyotrophic lateral sclerosis. Possibly success may also be achieved there by giving selenium and Vitamin E.

Selenium from the BIOFRID Company

In the food supplement Selen-BIOFRID the essential trace



element selenium is present as L-Selenomethionine. This guarantees good assimilation and utilisation in the body. It has a bio-availability of 90%!

One capsule of Selen-BIOFRID contains 30 µg of selenium. Our recommended consumption is: one capsule daily with a meal as a food supplement. Logical support for this dosage would be a daily dose of 10 drops of SELENOKEHL 4X (SANUM-Kehlbeck)

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