INFORMATION SHEET

BIO-FORT SELENIUM

Cellular Health: The key to life

Your body's cells live, work and die in a constant cycle of supporting and serving your body's systems, hence Cellular Health is the key to overall bodily health. Think of them as links in the chain - if all your cells are happy and in good condition, then your overall health will be at its best.

Properly maintained cells reproduce more correctly, resist oxidative stress, fight deterioration, live longer and even die properly (apoptosis) so that the surrounding healthy cells are not compromised.

Several trace minerals (such as iron, zinc and calcium) play a vital role in maintaining cellular health and functionality. Selenium is among the most important of these.

Cellular health depends largely on minimising "free radicals" which are produced during respiration and other cellular processes, and are increased by most diseases. Free radicals are particularly damaging to cellular components, including DNA and cell membranes. Free radicals also accelerate the ageing process. When the generation of free radicals in a system exceeds the systems' ability to neutralise and eliminate them, cells (and hence tissues and we ourselves) are said to be under oxidative stress. Selenium, in the form of certain selenoenzymes, has important antioxidant properties, that include "mopping up" free radicals and alleviating oxidative stress.

Most of us, however, do not consume enough selenium to maximise health and longevity and minimise disease risk.

Selenium must also be supplied to our body in the right form to function effectively and provide us additional health benefits.

Selenium

Selenium is an essential trace mineral that functions largely in the form of proteins, called selenoproteins, which act as enzymes and help prevent damage to cells in the body by oxidants in the environment or those produced by normal metabolism.

Selenium is named after Selene the goddess of the moon. It is one of the rarest of the elements on earth, and is a key component in all living systems. Without it, humans or animals could not develop properly or survive for long. Therefore, it is classed as an essential micronutrient for humans and animals and plants alike. It is located in Group 16 on the Periodic Table of the Elements and is classified "non-metallic". Non-metals are not able to conduct electricity or heat very well. As opposed

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to metals, non-metallic elements are very brittle, and cannot be rolled into wires or pounded into sheets. The non-metals exist in two of the three states of matter at room temperature: gases (such as oxygen) and solids (such as carbon). The non-metals have no metallic luster and do not reflect light. They have oxidation numbers of ±4, -3, and -2.

The important biological actions of Selenium (such as antioxidant, anti-cancer and anti-heart disease effects) are not properties of the element per se, but rather of its various chemical forms. The most common inorganic Selenium forms are selenite and selenate, while two of the major organic forms are selenomethionine (the major form in food) and selenocysteine (the 21st amino acid, and component of selenoproteins, many of which have vital enzyme functions in the body). Most Selenium ingested by humans comes from the soil, taken through plants growing in the soil. Fish is also an important dietary source of Selenium.

We are fortunate that plants such as cereals are able to extract Selenium from the soil, convert it into the most suitable forms for humans to eat (selenomethionine and other organic Selenium forms), and store it in their edible parts (e.g. grain).

It is important that people of all ages incorporate adequate daily levels of Selenium into their diet. Inadequate intake of selenium will result in adverse health consequences. There is evidence that infants who are low in the element are at higher risk of infections and other conditions associated with high oxidative stress, such as cot death. This is more likely if the mother has smoked and/or consumed a poor diet during pregnancy. In fact, pregnant or lactating women should eat more Selenium. Other groups at risk of insufficient Selenium intake and its consequences include smokers (especially men), the frail elderly, and anyone else who is subject to oxidative stress.

Why is Selenium important for humans? The following information summarises major research findings on the effects of Selenium on human health:

Reducing risk and progression of cancer:

World Selenium expert, Professor Gerald Combs from the USA has stated: “There is no more extensive body of evidence for the cancer preventive potential of a normal dietary component than there is for selenium.” (Pharmacology & Therapeutics 1998; 79: 179-192). Forty years of research has shown that low Selenium soil levels and intakes tend to be associated with higher cancer incidence and mortality.

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Enhancing immunity:

Selenium is essential to maintain an effective immune system, has diverse roles, and is normally abundant in immune tissues such as liver, spleen, and lymph nodes. Selenium deficiency reduces immunity, and supplementation of even supposedly selenium-replete individuals improves immunity by stimulating neutrophils, natural-killer-cells, T & B lymphocytes and macrophages. In addition, Selenium assists the immune system through its anti-viral effects.

Anti-asthma, rheumatoid arthritis, muscular dystrophy, cystic fibrosis, pancreatitis effects:

Antioxidant effects:

Free radicals are atoms or groups of atoms with an odd (unpaired) number of electrons and can be formed when oxygen interacts with certain molecules. Once formed these highly reactive radicals can start a chain reaction, like dominoes. Their chief danger comes from the damage they can do when they react with important cellular components such as DNA, or the cell membrane. Cells may function poorly or die if this occurs. To prevent free radical damage the body has a defence system of antioxidants. Antioxidants are molecules which can safely interact with free radicals and terminate the chain reaction before vital molecules are damaged.

Selenium's vital roles in the body are mostly conducted by selenoenzymes, of which at least 35 have been discovered. They include selenoprotein P (selenium transporter in the blood and brain), the thioredoxin reductases (maintenance of cellular oxidation-reduction balance, and synthesis of DNA), and the glutathione peroxidase family. New selenoenzymes are being discovered all the time! The glutathione peroxidases reduce harmful hydroperoxides and scavenge free radicals that cause continual damage to cells.

Diseases & Conditions:

Selenium can alleviate other conditions (in addition to heart disease, diabetes and some cancers) associated with high levels of inflammation and oxidative stress. Individuals with asthma, for example, tend to have increased oxidative activity, lowered selenium status, and decreased activity of glutathione peroxidase. Published studies of selenium deficiency and the preventive and clinical effects of selenium supplementation on asthma support the concept of selenium administration.

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Anti-ageing effects:

Free radicals are atoms or groups of atoms with an odd (unpaired) number of electrons and can be formed when oxygen interacts with certain molecules. Once formed these highly reactive radicals can start a chain reaction, like dominoes. Their chief danger comes from the damage they can do when they react with important cellular components such as DNA, or the cell membrane. Cells may function poorly or die if this occurs. To prevent free radical damage the body has a defense system of antioxidants.

Reducing heart disease and diabetes risk:

Selenium's antioxidant action reduces damage to lipids, lipoproteins and DNA, and alleviates inflammation/platelet aggregation, and hence reduces risk of heart disease. Moreover, it helps regulate blood pressure and can reduce blood homocysteine level, two important heart disease risk factors.

Helping to control dangerous viruses:

Selenium has a direct effect against RNA viruses like influenza, measles, polio, hepatitis B & C, and HIV. When Selenium is deficient, or even merely marginal, the viruses become more active and virulent. Studies have shown Selenium deficiency to be associated with faster progression to AIDS among HIV-positive individuals, and increased risk of progression to fibrosis, cirrhosis and liver cancer in people with hepatitis B or C.

Improving brain function:

Several selenoenzymes have important roles in the brain (e.g. selenoproteins M, P & W; glutathione peroxidase; thioredoxin reductase), where they are potent protective agents for neurons. Low Selenium levels have been associated with cognitive impairment, depression, anxiety and hostility. In one study, the brain selenium levels in Alzheimer's patients was only 60% of that in controls. Selenium supplementation can reduce cognitive decline in the elderly, probably by preserving dopamine and neurons in the substantia nigra, and by reducing lipid peroxidation.

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Improving fertility:

In men, Selenium is necessary for testosterone biosynthesis and also for sperm development and function. In women, Selenium, due to its antioxidant effects, can reduce the risk of miscarriage.

Important thyroid function role:

The thyroid gland has the highest Selenium and Iodine concentrations of all organs in the human body. Both Selenium and Iodine are required for thyroid hormone synthesis, activation and metabolism.

Other Selenium health benefits:

Selenium is a co-factor for the enzyme glutathione peroxidase, which aids in the regeneration of glutathione. It is also a major antioxidant nutrient that protects cell membranes and prevents free radical generation, thereby decreasing the risk of cancer and disease of the heart and blood vessels. Glutathione and glutathione related enzyme precursors riboflavin and selenium are protective against Age-Related Macular Degeneration (ARMD) (Sternberg, Davidson, Jones, et al. Invest Ophth Vis Sci,1993). Several studies indicate a role for Selenium in the treatment of severe bacterial infections, such as acute septicaemia. This is particularly relevant in view of increasing resistance of bacteria to standard antibiotics. Moreover, low Selenium status is an important risk factor for developing mycobacterial disease (e.g. tuberculosis) in HIV-positive individuals.

Evidence is accumulating for important interactions of Selenium with various other minerals in the body, including zinc, copper, iron and manganese. Selenium appears to have a normalising effect on other minerals in organs and blood cells. For example, a Serbian study found that marginally low zinc, iron and copper levels, along with abnormally high manganese levels in red blood cells were all normalised after people consumed Selenium-enriched wheat, while low-Selenium wheat had no effect. Selenium is a well-known detoxifier of toxic metallic pollutants. It has a high affinity for toxic metals such as cadmium and mercury, and for the metalloid arsenic, binding with them and rendering them harmless. In the case of cadmium and mercury, detoxification is achieved through the diversion in their binding from low- to high-molecular-weight proteins.

Numerous studies have found that Selenium and other antioxidants and phytochemicals have the effects of both enhancing the anti-cancer action of chemotherapy and radiotherapy and reducing the damage caused by these therapies

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to normal cells. With Laucke Bio-Fort Golden Wholemeal products you will get better cellular uptake and utilisation of key micronutrients like Selenium, together with longer-term bioavailability, in a safe and wholesome bread mix.

Selenium Availability:

While the ultimate source of all Selenium is the rocks and soils of our terrestrial environment, it is known that Selenium is not evenly distributed in soils, is not necessarily readily available to plants, and that the levels of availability are falling. While some areas of the world are rich in Selenium, many areas are known to be deficient. The availability of what Selenium is present can be affected by leaching by rain and irrigation, by aeration and by the addition of chemicals. Therefore, it is a matter of concern that available Selenium levels in humans are variable, and are reportedly falling, leading to increasing levels of Selenium deficiency. While various methods are used to supplement Selenium in animals, such interventionist methods as “chemical drenching” are not considered desirable nor suitable for humans. Authorities in Finland and New Zealand, where soils have been recognised as being Selenium deficient, have instituted Selenium Supplementation of soils using plant fertilisation to raise the amount of Selenium in parts of the food chain.

Biofortification:

Biofortification may be defined as the process of producing food crops that are rich in bio-available nutrients. This process of Bio-Fortification is typically performed by including higher levels of Bioavailable nutrients in plants, which may be then directly or indirectly consumed as food. Plants take up these extra nutrients because more nutrients are made available to the plant, or because plant breeders actively select plant varieties that more efficiently seek and include nutrients. With food crops that are rich in bio-available micronutrients, farmers can provide crops that provide increased nutrition and health benefits. Increased micronutrient and vitamin density in grain destined for human consumption may alleviate deficiencies that affect a majority of the world’s population. Food researchers have been focussing on iron [Fe], zinc [Zn], iodine [I], vitamin A, and most recently, Selenium [Se]. HarvestPlus is an example of an international, interdisciplinary research program that seeks to reduce micronutrient malnutrition by harnessing the powers of agriculture and nutrition research to breed nutrient-dense staple foods. Its current focus is on Fe, Zn and vitamin A.

Substantial genetic (genotypic) variation has been found in cereals for Zn, Fe and vitamin A (Graham et al, 2001), which means that varieties high in these nutrients can be bred. Moreover, agronomic methods involving application to the soil, in

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irrigation water or to the leaves (foliar) can be effective for Zn (soil and to a lesser extent foliar), Fe (foliar only), and I (irrigation water) (Rengel et al, 1999). However, Selenium can be added to plants more efficiently than these and most other micronutrients by any of these methods. Biofortification with Selenium may involve supplementation of livestock, fertilisation of food crops or breeding food crop varieties with enhanced Selenium uptake efficiency to achieve higher Selenium density in edible parts. Supplementation of livestock with Selenium is unlikely to be an efficient strategy to increase Selenium level in the human population. In New Zealand, little increase in the Selenium content of human foods was observed after the introduction of Selenium supplementation for farm animals in the 1960s (Thomson & Robinson, 1980). However, Selenium in the selenate form is readily taken up by plants, converted into organic forms (which are very suitable for humans and animals), and loaded into grains and other edible parts.

The addition of selenate to NPK fertilisers for use on crops and pastures in Finland since 1984 has been an effective and safe method to increase the entire population's Selenium status (Aro et al, 1995). This fertilisation approach can be termed agronomic Biofortification. Selenium fertilisation has generally not been found to increase yield in most crops, although some researchers have found yield increases (Hartikainen, 2005). Another option is plant breeding, or genetic biofortification, which represents a selfsustaining Selenium biofortification strategy. As noted above, substantial variability exists within cereal crop varieties for Zn, Fe and other nutrients (Graham et al, 2001). However, because grain Selenium concentration is mostly determined by the amount of available Selenium in the soil, with genotypic variation small in comparison, (Lyons et al, 2005), a breeding approach may not be worthwhile. Biofortification is likely to be the most feasible method to increase Selenium status in most situations as it represents a food systems approach that can deliver increased Selenium to a whole population safely, effectively, efficiently and in the most suitable chemical forms. A food systems paradigm encompasses an agriculture that aims not only at productivity and sustainability, but also at improved nutrition (Welch & Graham, 1999).

Field and glasshouse trials have been conducted in South Australia by researchers from the University of Adelaide's School of Agriculture & Wine, and the most efficient methods of Selenium biofortification have been adopted by Laucke Flour Mills.

Advantages of cereal grains biofortified with Selenium:

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- More efficient absorption by the body than inorganic forms of Selenium, and thus greater bioavailability.
- Absorption from the gut of vitamin C is not reduced by organic Selenium forms in biofortified cereals, unlike the form sodium selenite.
- Longer-term retention in the body. Most biofortified Selenium is in the selenomethionine form. This form is incorporated into muscle tissue and the Selenium released when required, whereas a substantial proportion of inorganic Selenium (sodium selenate & sodium selenite) is excreted. More on selenomethionine below.
- Cereals biofortified with Selenium have significantly higher antioxidant activity (ability to scavenge damaging free radicals, and protection against lipid peroxidation) (Hu et al, 2004; Xu & Hu, 2004). Bio-Fort wheat is likely to be one of the most effective Selenium forms to protect against cancer. In animal trials in the USA high-Selenium wheat was the most effective Selenium form in reducing the incidence of colon cancer precursors (Finley & Davis, 2001).
- Selenium taken in the form of Bio-Fort wheat products provide the added benefits of whole grains. For example, phytate, which is abundant in bran, is one of the best natural anti-cancer substances known. Whole-grains also provide additional dietry fibre, zinc, omega-3 fatty acids, vitamin E, and many additional antioxidants and beneficial phytochemicals.
- Milled Bio-Fort grain provides an even distribution of Selenium concentration throughout the grain ('wholegrain/wholemeal' and 'white' flour alike) - unlike other trace minerals (Zn, Fe, Cu, Mn, etc), Selenium is well distributed throughout the entire grain and not just in the outer 'bran' layers. There is minimal likelihood of ingesting too much Selenium, because the Selenium is incorporated naturally by the wheat plant and consumed as part of a normal, healthy diet.

With Laucke Bio-Fort Golden Wholemeal products you will get better cellular uptake and utilisation of key micronutrients like Selenium, together with longer-term bioavailability, in a safe and wholesome bread mix.

Selenomethionine:

Selenomethionine (Se-meth) is the Selenium analogue of the sulphur amino acid, methionine, in which the sulphur is replaced by Selenium. Se-meth is the major nutritional source of Selenium for higher animals and humans Since higher animals and humans are unable to synthesise Se-meth, yet from it all needed forms of Selenium are produced, Se-meth meets the criteria of an essential acid. Accordingly, Se-meth, or enriched food sources thereof, are appropriate forms of Selenium for

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human nutritional supplementation. It is generally better absorbed from the gut than are the inorganic Selenium forms. In high-Selenium wheat, maize and soybeans, 51-82% of the Selenium was found to be in the Semeth form.

Stored in muscle tissue and also rapidly taken up by the brain, selenomethionine is effective at increasing the activity of the antioxidant selenoenzyme, glutathione peroxidase, and also effective at increasing immunocompetence.

Importance of wheat as a dietary selenium source:

Selenium is generally more bioavailable from plant forms than from animal foodstuffs, and wheat Selenium is one of the most bioavailable forms (Lyons et al, 2003). Norway's population, despite a modest total Selenium intake, has the highest serum Selenium level in Europe at 119 µg/l. The probable explanation is that their major selenium source is relatively-high-Selenium North American wheat. In a Norwegian study, Meltzer et al (1992) demonstrated the high bioavailability of wheat-Selenium by feeding trial participants Selenium-rich bread providing 100, 200 or 300 µg Selenium daily for 6 weeks. Serum selenium increased in a dose-response manner by 20, 37 and 53 µg/l, respectively, in the three groups ($p<0.001$). Wheat enriched with Selenium by foliar application was found to be highly effective in raising plasma Selenium (53% increase after 6 weeks of 25 µg/d Selenium from wheat) in a Serbian study. Glutathione peroxidase activity in blood increased and oxidative stress parameters decreased (Djujic et al 2000a). A follow-up study found that Selenium-enriched wheat increased levels of copper, iron and zinc in erythrocytes, compared to individuals consuming low-Selenium wheat (Djujic et al 2000b). This is the first time such interactions have been reported, and further studies are warranted in view of the billions of people who are Fe (Iron) and/or Zn (Zinc) deficient.

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