Journal of Nutrition and Food Science Forecast

Dietary Silicon: Is Biofortification Essential?

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Editorial

Compelling evidence continues to accumulate indicating that silicon is a beneficial trace element and contributes to health. Data from human, animal, and *in vitro* studies demonstrate that dietary silicon increases bone mineralization, collagen synthesis, improves structural integrity of skin, hair and nails, modulates the immune system and inflammatory response, and mitigates the risk of atherosclerosis [1]. Others have shown beneficial effects on lipoprotein profiles and hepatic antioxidant defenses. Silicon deficiency as shown in animal studies induces deformities in skull and peripheral bones, poorly formed joints, reduces cartilage and collagen, and disrupts mineral balance in the femur and vertebrae. Cumulatively, this suggests strongly that silicon is, in fact, a necessary, and likely essential, dietary metalloid.

Many professionals in the nutritional sciences do not consider a trace element essential unless it has a defined biochemical function. For silicon, a plausible mechanism of action occurs via its binding of hydroxyl groups of polyhydroxylated organic compounds, which influence formation and/or use of glycosaminoglycans, mucopolysaccharides, and collagen in connective tissue and bone [2,3]. As a result, it is biologically plausible that dietary silicon contributes appreciably to biochemical function and may affect, as well, the absorption, retention or function of other minerals, e.g., aluminum.

A particularly exciting, recent result identifies silicon transporters in human cells. In fact, human aquaglyceroporins function as silicon transporters in human embryonic kidney cells and are relevant silicon permeation pathways in both mice and humans. This assertion is supported by the kinetics of substrate transport, presence of silicon in tissues where silicon exerts biological effects and transcriptional responses to changes in dietary silicon. Collectively, data suggest that silicon is, in fact, an important and presumably essential trace element nutrient needed for important biological functions, thus its whole-body distribution is regulated.

In other studies, a new mammalian efflux silicon transporter, a known sodium-phosphate cotransporter, is upregulated in rat kidney following chronic dietary silicon deprivation [4]. This suggests an important role for silicon in vertebrates and elucidates dietary phosphate and silicon interactions. Compelling, convincing support suggests silicon is, in fact, an indispensable factor in bone development and connective tissue health. However, debate continues regarding essentiality.

Healthful diets ideally should include foods that provide trace elements in amounts that reduce chronic disease risk and promote health even if not currently considered essential. A dietary intake of silicon of 25mg/d would be an adequate, efficacious intake with unlikely adverse effects. Dietary sources include unrefined grains, certain vegetables and beverages and cereals made from grains. Water-soluble silicon, viz., silicic acid (ortho, meta, di, and tri-silicates) are present in potable water (1-100 mg/L). Colloidal silicic acid, silica gel, and zeolites, although insoluble, can marginally increase concentrations of water-soluble, bioavailable silica. Although there are several potential dietary sources, silicon bioavailability from foods is low. Thus, it may be prudent to increase intake via other innovative means such as biofortification of edible parts of plants.

Development of new functional foods to improve nutritional status and mitigate nutritional deficiencies is a current food industry priority. As a result, silicon biofortification may be an innovative agronomic tool for producing new functional foods with beneficial effects on bone mineralization. In recent studies, the application of silicon to a nutrient solution for crops (50-100 mg/L) facilitated biofortification of six leafy vegetables and soilless cultivation significantly fortified silicon in green beans by three-fold [5]. Moreover, biofortified vegetables produced more bioaccessible (release from food matrix) silicon compared to unbiofortified vegetables. In subsequent studies, the bioavailable fraction of biofortified purslane and Swiss chard improved the expression of osteoblast markers, indicators of increased bone mineralization, compared with other

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Received Date: *18 Apr 2018*
Accepted Date: *08 May 2018*
Published Date: *11 May 2018*

Citation: *Martin KR. Dietary Silicon: Is Biofortification Essential?. J Nutri Food Sci Forecast. 2018; 1(2): 1006.*

ISSN 2643-8186

vegetables. *In vitro* digestion of leafy green vegetables and the use of cells in culture demonstrated increased total alkaline phosphatase activity and type 1 collagen, biochemical markers of bone formation. Indeed, it appears that biofortification may be an effective means of increasing silicon bioavailability and ultimately improve bone health.

Collectively, new evidence strongly suggests that silicon is an important biological element in humans and that its body distribution is regulated, in part, via mammalian transporters. Much more research is needed to elucidate the specific physiological role(s) of silicon in humans as well as the effects of chemical speciation of health-promoting forms of silicon, i.e., silicic acid, on relative bioavailability.

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