# SILICON and orthosilicic acid (a highly bioavailable form of silicon)

Within the last decade silicon has been recognized as participating in the normal metabolism of higher animals and as being an essential trace element. Silicon is found to perform an important role in connective tissue, especially in bone and cartilage. Bone and cartilage abnormalities are associated with a reduction in matrix components, resulting in the establishment of a requirement for silicon in collagen and glycosaminoglycan formation. Silicon's primary effect in bone and cartilage is on the matrix, with formation of the organic matrix appearing to be more severely affected by silicon deficiency than the mineralization process[1].

There is perhaps no question that silicon appears to have a beneficial role in bone formation and in bone health. Since the findings of Carlisle[2] and Schwarz & Milne[3] of a potential role of silicon in bone and connective tissues, there have been numerous studies over the past 30 years investigating this potential role of dietary silicon[4].

Also, while there are numerous factors that contribute to bone health and to therapy for postmenopausal osteoporosis, silicon is also a mineral that is increasingly recognized as an essential nutrient for bone formation and maintenance. More attention to this important nutrient by the medical community may lead to improved dietary supplements and better understanding of the role of silicon in management of postmenopausal osteoporosis[5].

Evidence coming from human, animal, and in vitro studies, indicate that silicon in nutritional and supra nutritional amounts promotes bone and connective tissue health, may have a modulating effect on the immune or inflammatory response, and has been associated with mental health. A plausible mechanism of action for the beneficial effects of silicon is the binding of hydroxyl groups of polyols such that it influences the formation and/or utilization of glycosaminoglycans, mucopolysaccharides, and collagen in connective tissue and bone. In addition, silicon may affect the absorption, retention or action of other mineral elements (e.g., aluminum, copper, magnesium). The results of a number of studies suggest that dietary silicon supplementation could be of therapeutic value for preventing chronic aluminum accumulation in the brain[6].

Based on findings from both animal and human experiments, an intake of silicon of near 25mg/d would be a reasonable suggestion for an adequate intake that would assure its nutritional benefits. Increased intakes of silicon through consuming unrefined grains, certain vegetables, and beverages and cereals made from grains should be recognized as a reasonable dietary recommendation[7].

Silicon strengthens and makes the walls of blood vessels more flexible, diminishes capillaries permeability, accelerates healing processes, has a sebostatic activity, strengthens hair and nails[8]. In in vivo studies, Si stimulated the expression of peroxisome proliferator-activated receptor-$\gamma$, the activation of which has anti-inflammatory and antihypertensive effects on vascular cells[9].

Silicon has been shown to suppress the production of inflammatory cytokines and mediators, possibly through the suppression of radical scavenger activity and down-regulation of gene expression of inflammatory mediators[10].

Ortho-silicic acid ($H_4SiO_4$), as a major form of bioavailable silicon for both humans and animals, has not been given adequate attention so far. Ortho- silicic acid is the form predominantly absorbed by humans and is found in numerous tissues including bone, tendons, aorta, liver and kidney. Compelling data suggest that silica is essential for health although no

RDI has been established. However, deficiency induces deformities in skull and peripheral bones, poorly formed joints, reduced contents of cartilage, collagen, and disruption of mineral balance in the femur and vertebrae[11].

One possible mechanism by which silicon affects collagen type 1 synthesis may be related to a possible role in the regulation of prolyl hydroxylase activity. In vitro results show a stimulatory effect of ortho-silicic acid on collagen synthesis and osteoblast differentiation which suggest that this compound may have a stimulatory effect on bone formation in vivo[12].

There is considerably less research on supplementation with stabilized OSA. A study conducted on calves demonstrated the high bioavailability of silicon from OSA. With just a 4.9% increase in dietary Si intake from supplemental choline-stabilized OSA, the treated group had a 70% higher serum Si concentration than control calves after 23 weeks[13]. OSA was able to alter mineral absorption in a positive manner, and would be a valid option as bone health supplement for the horse[14].

In men, choline stabilized ortho-silicic acid supplementation was found effective in reducing symptoms of knee OA, which was associated with a slight but significant reduction of biomarkers that are related to cartilage degradation[15].

In women, oral intake of choline stabilized ortho-silicic acid during 20 weeks resulted in a significant positive effect on skin surface and skin mechanical properties, and on brittleness of hair and nails[16].

Combined therapy of choline stabilized ortho-silicic acid and Ca/Vit D3 had a potential beneficial effect on bone collagen compared to Ca/Vit D3 alone which suggests that this treatment is of potential use in osteoporosis[17].

## Selected bibliography


1. **Silicon as an essential trace element in animal nutrition**. Carlisle EM. Ciba Found Symp. 1986;121:123-39.
2. **Carlisle EM. Silicon: an essential element for the chick**. Science. 1972;178:619.
3. **Schwarz K, Milne DB. Growth promoting effects of silicon in rats**. Nature. 1972;239:333–334.
4. **Silicon and bone health**. Jugdaohsingh R. J Nutr Health Aging. 2007 Mar-Apr;11(2):99-110
5. **Silicon: A Review of Its Potential Role in the Prevention and Treatment of Postmenopausal Osteoporosis** Price, C. T., Koval, K. J., & Langford, J. R. (2013). International Journal of Endocrinology, 2013, 1–6.
6. **Oral silicon supplementation: an effective therapy for preventing oral aluminum absorption and retention in mammals**. Domingo JL, Gómez M, Colomina MT. Nutr Rev. 2011 Jan;69(1):41-51
7. **Update on the possible nutritional importance of silicon**. Nielsen FH. J Trace Elem Med Biol. 2014 Oct;28(4):379-82
8. **Biological function of some elements and their compounds. IV. Silicon, silicon acids, silicones.** Puzanowska-Tarasiewicz H, Kuźmicka L, Tarasiewicz M. Pol Merkur Lekarski. 2009 Nov;27(161):423-6.
9. **Soluble silica and coral sand suppress high blood pressure and improve the related aortic gene expressions** inspontaneously **hypertensive rats**. Maehira F, Motomura

K, Ishimine N, Miyagi I, Eguchi Y, Teruya S. Nutr Res. 2011 Feb;31(2):147-56
10. **Analysis of** antioxidant **and anti-inflammatory activity of silicon in murine macrophages**. Kim EJ, Bu SY, Sung MK, Kang MH, Choi MK. Biol Trace Elem Res. 2013 Dec;156(1-3):329-37
11. **The chemistry of silica and its potential health benefits**. Martin KR. J Nutr Health Aging. 2007 Mar-Apr;11(2):94-7
12. **Orthosilicic acid stimulates collagen type 1 synthesis and osteoblastic differentiation in human osteoblast-like cells in vitro**. Reffitt DM, Ogston N, Jugdaohsingh R, Cheung HF, Evans BA, Thompson RP, Powell JJ, Hampson GN. Bone. 2003 Feb;32(2):127-35
13. **Supplementation of calves with stabilized orthosilicic acid. Effect on the Si, Ca, Mg, and P concentrations in serum and the collagen concentration in skin and cartilage**. Calomme MR, Vanden Berghe DA.Biol Trace Elem Res. 1997 Feb;56(2):153-65.
14. **Mineral balance in horses fed two supplemental silicon sources.** O'Connor CI1, Nielsen BD, Woodward AD, Spooner HS, Ventura BA, Turner KK. J Anim Physiol Anim Nutr (Berl). 2008 Apr;92(2):173-81
15. **A 12-week randomized, double-blind, placebo-**controlledmulticenter **study of choline-stabilized orthosilicic acid in patients with symptomatic knee osteoarthritis.** Geusens P, Pavelka K, Rovensky J, Vanhoof J, Demeester N, Calomme M, Vanden Berghe D. BMC Musculoskelet Disord. 2017 Jan 5;18(1):2
16. **Effect of oral intake of choline-stabilized orthosilicic acid on skin, nails, and hair in women with photodamaged skin.** Barel A, Calomme M, Timchenko A, De Paepe K, Demeester N, Rogiers V, Clarys P, Vanden Berghe D. Arch Dermatol Res. 2005 Oct;297(4):147-53
17. **Choline-stabilized orthosilicic acid supplementation as an adjunct to calcium/vitamin D3 stimulates markers of bone formation in osteopenic females: a randomized, placebo-controlled trial.** Spector TD, Calomme MR, Anderson SH, Clement G, Bevan L, Demeester N, Swaminathan R, Jugdaohsingh R, Berghe DA, Powell JJ. BMC Musculoskelet Disord. 2008 Jun 11 ;9:85.