

Research and Analysis on the Health Effects of Metasilicic Acid Drinking Water

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Abstract: With the change of dietary structure and the improvement of health awareness of Chinese residents, the public's attention to silicon content in food and drinking water is also increasing. Studies show that silicon has important functions for human health, and drinking water is the most common and safest way for human body to ingest silicon. In particular, it is particularly important to ingest silicon in metasilicic mineral water. In this paper, the existing forms of silicon in nature and the relationship between silicon and human health are studied in order to provide help and reference for the detection of silicon content in food and drinking water and the quality evaluation of mineral water.

Keywords: Metasilicate; Drinking Water; Healthy

1. Introduction

Metasilicic acid is also called silicic acid. Relevant information reports: Recent studies [1] show that silicon may have important functions for human health, and food and drinking water are the most common and safest ways for human body to ingest silicon [2]. With the change of dietary structure and the improvement of health awareness of Chinese residents, the public pays more and more attention to the functional components in diet, among which the understanding of silicon in diet is quite representative, and the attention to silicon content in food and drinking water is also increasing.

2. Physical and Chemical Characteristics and Existing Forms of Silicon

Silicon is the 14th element in the periodic table of elements, with an atomic weight of 28.09. It is the second most abundant element in the earth's crust, accounting for 26.4% of the total mass of the earth's crust. Silicon rarely exists in nature in the form of simple substance, but

widely exists in rocks, gravels and water bodies in the form of complex silicates (most of which are aluminosilicates) or SiO_2 . The solubility of SiO_2 in water is extremely low, but it can form a variety of water-soluble silicic acids. The silicic acids that can exist independently and have certain stability include metasilicic acid, metasilicic acid, orthosilicic acid ($\text{Si}(\text{OH})_4$) and pyrosilicic acid, which mainly exist in the form of monomer orthosilicic acid or its polymer in natural water. Because metasilicic acid is the most basic form of all silicic acids, metasilicic acid is often used to characterize the concentration of silicic acid in water [3].

Metasilicic acid, chemical formula " H_2SiO_3 ". Under the pressure of ancient rocks for hundreds of millions of years, under the action of maintaining low temperature and constant temperature, silicon dioxide gradually dissolved in the water of weathered cracks and confined cracks in granite, forming metasilicic acid.

Natural mineral water is a kind of groundwater, which mainly exists in deep underground rock cavities and the gaps of crustal materials, and is different from surface water and shallow groundwater. The content of metasilicic acid is one of the important boundary indicators used to identify whether natural mineral water meets the standard in China. The seven boundary indicators stipulated in the national standard (National Standard for Drinking Natural Mineral Water for Food Safety)(GB 8537-2018)include Lithium, Strontium, Zinc, Metasilicate, Selenium, Free Carbon Dioxide, Total Dissolved Solids, and one or more of the mineral water must meet the requirements of the boundary indicators.

Table 1. Boundary Indicator

| Project | Requirement | Method |
|------------------|-------------|------------|
| Lithium/(mg/L) | 0.20 | GB 8538 |
| Strontium/(mg/L) | 0.20 | |
| Zinc/(mg/L) | 0.20 | |

| | | |
|-------------------------------|------|--|
| Metasilicate/(mg/L) | 25.0 | |
| Selenium/(mg/L) | 0.01 | |
| Free Carbon Dioxide/(mg/L) | 250 | |
| Total Dissolved Solids/(mg/L) | 1000 | |

As shown in the Table 1, when the content of metasilicic acid is $\geq 25\text{mg/L}$, this well can be characterized as metasilicic natural mineral water. However, due to the influence of dry season and water temperature, the metasilicic acid in water will be unstable. Under normal circumstances, the detection amount of metasilicic acid in source water should exceed 30mg/L , so as to ensure the metasilicic acid content in finished water to be stable above 25mg/L .

3. Geological Distribution and Content of Silicon Metasilicate

Studies have shown that most natural water bodies contain a certain amount of silicon, but the content of metasilicic acid is generally less than 10mg/L . According to the data of 188 kinds of bottled water marked with metasilicic acid collected by our research group, the content is mostly between $25\sim 90\text{mg/L}$ [1]. The water containing metasilicic acid is widely distributed in China and found in many provinces, municipalities and autonomous regions. China's metasilicic mineral water (metasilicic acid $\geq 25.0\text{mg/L}$) is mainly distributed in Jilin, Fujian and Guangdong GuangXI [4], and the Chinese Academy of Geological Sciences also studies that the mineral springs with H_2SiO_3 content of 25mg/L are mainly distributed in Guangdong, Fujian, Guangxi, Hainan and other provinces and regions in the southeast coastal areas, Liaodong and Shandong Peninsula, mainly in lithologic zones such as granite, basalt and sandstone [5], and Zhou Changsong's research group investigated and analyzed that metasilicate mineral water is mainly distributed in volcanic rock and magmatic rock areas [6]. The content of metasilicic acid in this kind of mineral water is between $25\sim 90\text{mg/L}$, and there are also mineral waters with metasilicic acid content above 160mg/L [1]. The results of investigation and study on local water quality by relevant research institutions are basically consistent with the above research. For example, the hot spring water in Hot Water Village, Heyuan, Guangdong

Province, has a water temperature of 98°C , and the content of metasilicic acid in the water is 151.04mg/L . A mineral spring belt with high metasilicic acid content of 56mg/L , pH value of 7.4 and total hardness of 54.99mg/L is suitable for drinking. The rocks in Qingdao, Shandong Province also belong to silicates. After weathering or groundwater alteration, various clay minerals can be formed, which can release free silica. When the free silica is dissolved in water, it forms metasilicic acid, and its metasilicic acid content reaches 25.49mg/L [7]. The average content of metasilicic acid in spring water samples of four spring groups in Jinan is 20.37mg/L , which also belongs to water bodies with high metasilicic acid content [8]; Wuliashan rock in Wulian County, Rizhao City belongs to typical geode medium-grained adamellite, and the content of metasilicic acid in mineralized mountain spring is $37.6\sim 79\text{mg/L}$, which belongs to typical metasilicic mountain spring. For ordinary people, it is of certain significance for the body to supplement silicon if they can drink this kind of drinking water for a long time.

At present, most of the common drinking water sources of metasilicic acid in China's market come from the above areas. For example, Laoshan mineral water, Master kong Hanyangquan metasilicate mineral water and Arctic spring natural mineral water, Evergrande Spring metasilicate water, etc. The metasilicate content in these mineral waters is $50.7\sim 78.6\text{mg/L}$ for Evergrande Spring, $25\sim 55\text{mg/L}$ for Laoshan mineral water, $30\sim 75\text{mg/L}$ for Master kong Hanyangquan metasilicate mineral water and $25\sim 70\text{mg/L}$ for King hundred mountain mineral water. Mineral mineral water: $25\sim 50\text{mg/L}$, Yili natural mineral water: $35\sim 70\text{mg/L}$, Nongfu Spring: $30\sim 50\text{mg/L}$, Bama mineral water: $26\sim 50\text{mg/L}$. In particular, the content of metasilicic acid in the metasilicic acid water of Evergrande Spring is relatively high, which is higher than that of similar products sold in the domestic market. The natural metasilicic acid mineral water of Evergrande Spring Changbai Mountain comes from Changbai Mountain. Changbai Mountain, together with European Alps and Russian Caucasus Mountain, is also known as the three major gold water sources in the world, and is a typical compound volcano. Other sources of Master Kong's water

conservation springs are Changbai Mountain in Jilin and Leshan in Sichuan, King hundred mountain 's mineral water sources are Huizhou and Meizhou in Guangdong, Nongfu Spring's water sources are Qiandao Lake in Zhejiang, Wanlv Lake in Guangdong and Cuocho Spring in Jilin, Yili Natural Mineral Water Source is Jiaquan in Longtian Town, Longmen County, Huizhou City, Guangdong Province, and Bama Lilang Mineral Water Source is Changlv Mountain in Guangxi.

4. Metabolism of Silicic Acid in Human Body

The main form of silicic acid in water is orthosilicic acid, which is a neutral molecule with simple structure, easily penetrates the mucous layer of digestive tract, and is absorbed into blood by mucosal cells through energy-saving paracellular pathway or intercellular pore pathway, and absorption mainly occurs in the proximal part of small intestine. Silicic acid molecules in blood are mostly free and do not combine with blood proteins, which is also the reason why they are easily excreted by the kidney.

Studies have shown that the absorption rate of orthosilicic acid in human body is 43~50%, which can reach the peak of blood in a short time and is easily excreted by the kidney. The metabolic kinetics of 8 healthy volunteers was studied by our research group. The results showed that the blood silicon reached its peak after 60~84min, and the urine silicon reached its peak after 24~32h after intake of water containing orthosilicic acid 27~55mg/L, and the urine silicon excretion rate M value was 50.3%[1]. Studies have proved that [9]: Silicon in food is easy to be utilized, which is consistent with rapid absorption and excretion. Generally speaking, the average amount of silicon absorbed is (40.9±36.3)% excreted in urine within 6 hours, which also confirms that silicon in food and plants is digested and absorbed through the gastrointestinal tract.

It is reported that experts in Germany and Japan have concluded that the metabolic process of metasilicic acid discharged from the kidney after it is absorbed from the intestine in human body is very clear, and the excess silicon in the body will not accumulate in the body, and 100% of people's kidneys will be discharged from the body.

5. Effect of Silicic Acid on Human Health

Silicon mainly exists in connective tissue and epidermal tissue of human body, and it is the highest in bone and aorta, which are 18 and 16μg/g respectively, followed by tendon 12μg/g and skin 4μg/g[10]. In epidermal tissue, the dermal layer of skin is rich in connective tissue and needs the participation of silicon, while hair and nails are rich in keratin, and keratin also needs the participation of silicic acid to form a complete structure and function [11].

The influence of silicon on human health is mainly manifested in [1]: First, it can promote the health of bones. So far, many research papers on the relationship between silicon and bones have been published internationally, including animal experiments, population epidemiological studies and in vitro cell experiments, and the conclusions consistently show the positive effect of silicon on bone health. Silicon can improve the ability of bone cells to synthesize collagen fibers, stimulate bone cells to secrete osteoprotegerin, improve the speed and quality of bone mineralization, and promote the body to absorb beneficial elements of copper, calcium, magnesium and other bones. Second, it has a preventive effect on cardiovascular diseases, which is mainly reflected in the protection of silicon on aorta. Through the cross-linking ability, mucopolysaccharides in blood vessel walls are closely combined with collagen fibers and elastic fibers, thus maintaining the complete structure and elasticity of arteries and resisting the occurrence of atherosclerosis. Third, it has preventive and adjuvant therapeutic effects on Alzheimer's disease, which is manifested in that silicon can easily combine with aluminum to form a complex, and orthosilicic acid can prevent aluminum from being absorbed in the gastrointestinal tract. In an intervention study, volunteers drank 1L of silicon-rich mineral water every day for 12weeks. In the control group and Alzheimer's patients group, urinary aluminum excretion increased, but urinary iron and copper excretion did not increase. At the same time, silicon has an auxiliary treatment effect on multiple sclerosis, a nutritional support effect on epidermal tissue, and a recovery effect of silicon-rich mineral water on chronic nephritis.

Silicon is defined by WHO as an essential trace element for human body, but the

recommended minimum intake of silicon in diet has not been put forward yet. Studies [12] suggest that the daily intake of silicon higher than 40mg (equivalent to 111.2mg/d of metasilicate) may be beneficial to the body's bone and cardiovascular health.

6. Human Body's Intake and Utilization Of Silicon

Silicon is an essential trace element for human body. In 1996, the FAO/IAEA/WHO Joint Expert Committee classified silicon as a possible essential trace element for human body. Most foods contain different levels of silicon, such as grasses and their seeds (i.e. all kinds of cereals), vegetables, fruits, tea and their derivative foods, such as beer, red wine, coffee and tea, etc., but most of the silicon in foods exists in the form of phytic silicon, aluminum silicate or silicon dioxide, which has low water solubility and low absorption rate. Only water-soluble monomer orthosilicic acid can be absorbed and utilized by people and animals[13]. There is evidence that because silicon mainly exists in plant fiber tissues, it is easy to lose silicon in food during refining. For example, the silicon content of whole oats and whole rice is reduced to 3%~20% after refining, and the higher the refining degree, the greater the loss of silicon content.

It is also reported that the human body can obtain soluble silicon in food by eating beer, grains, vegetables and fruits, but most of the silicon in solid foods such as grains, vegetables and fruits cannot be directly absorbed. By cooking or decomposition of gastric acid, it can be absorbed by the human body. 41% ~ 86% of the silicon absorbed and utilized by the human body comes from corn flakes, white rice and brown rice, and 50% ~ 86% comes from mineral water. Among people who drink metasilicate-rich mineral water for a long time, the proportion from mineral water will increase obviously [9].

Because the absorption and utilization of silicon in solid foods are affected by the solubility of silicon salts and cellulose and organic macromolecules in the diet, even silicon-rich foods (beans and their products, brown rice, bananas, etc.) are not ideal. From this point of view, it is particularly important for the body to ingest silicon from drinking water, especially metasilicate mineral water.

7. Concluding Remarks

To sum up, from the current research results, silicon has a positive effect on human health, especially metasilicate drinking water is a good source of silicon intake and absorption. Some data suggest that [1] special people can supplement water-soluble silicon through drinking water. Because metasilicic acid has a good function of softening blood vessels, it can obviously relieve arteriosclerosis, cardiovascular and heart diseases, especially for the elderly, and has great potential value in preventing osteoporosis, maintaining blood vessel health, and improving senile dementia and multiple sclerosis. Drinking metasilicate water for pregnant women and children can help their bones grow and develop.

At the same time, although metasilicic acid has many benefits to human body, it is suggested that we treat this problem rationally. Although metasilicic mineral water is good, it cannot be compared with health care products and medicines, nor can it play a role in curing all diseases. We should also apply it according to our own situation. When we choose metasilicate mineral water, we should pay attention to whether the metasilicate content in mineral water meets the standard, and pay attention to the parameters marked on the bottle: the content of trace elements and the content of limited indicators. There are also data showing that excessive drinking of metasilicate mineral water may increase the burden on the kidneys, and to a certain extent, there will be a disorder of uric acid metabolism, and it may even affect the normal metabolism of uric acid, resulting in an increase in uric acid.

The effect of silicon on human health need a lot of research. In this paper, the existing forms of silicon in nature, the relationship between silicic acid and human health, the silicon content in food and drinking water, and the absorption of silicon in human body are summarized and studied, so as to provide help and reference for professional and technical personnel to carry out silicon content detection and mineral water quality evaluation.

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