CHAPTER 5

Nutraceuticals with Mineral Origin

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CONTENTS

Introduction ............................................................................................................ 102
Calcium .................................................................................................................. 103
   Mechanism of Action .................................................................................... 103
   Absorption .................................................................................................... 103
   Distribution .................................................................................................. 103
   Elimination ................................................................................................... 103
   Bioavailability .............................................................................................. 104
   Uses ................................................................................................................ 104
Dietary Sources ................................................................................................. 104
Commercial Preparations .................................................................................. 104
Deficiency .......................................................................................................... 104
Adverse Effects, Contraindications, and Interactions ....................................... 104
Chromium .............................................................................................................. 105
   Mechanism of Action .................................................................................... 105
   Absorption .................................................................................................... 105
   Distribution .................................................................................................. 105
   Elimination ................................................................................................... 105
   Bioavailability .............................................................................................. 105
   Uses ................................................................................................................ 106
   Dietary Sources ........................................................................................... 106
Interactions and Side Effects .............................................................................. 106
Copper .................................................................................................................... 106
   Mechanism of Action .................................................................................... 106
   Absorption .................................................................................................... 106
   Distribution .................................................................................................. 106

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Manganese ............................................................................................................. 113
Magnesium ............................................................................................................. 111
Iron ......................................................................................................................... 109
Iodine ...................................................................................................................... 108

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Interactions

Adverse Effects and Side Effects

Deficiency

Dietary Sources

Uses

Bioavailability

Mechanism of Action

Distribution

Elimination

Potassium

Phosphorus

Molybdenum

Selenium

Introduction

Mechanism of Action

Absorption

Distribution

Elimination

Bioavailability

Uses

Deficiency

Dietary Sources

Uses

Commercial Preparations

Adverse Effects

Interactions

Adverse Effects, Contraindications, and Interactions

Deficiency

Dietary Sources

Uses

Bioavailability

Elimination

Distribution

Absorption

Mechanism of Action
INTRODUCTION

Minerals are simple inorganic elements. They are found in the body in the form of mostly salts. Four to 6% of the body weight is attributed to minerals. Almost half of it comes from calcium, and a quarter is phosphorus (phosphates); other essential minerals contribute to the whole picture. Calcium plays a major role in skeletal muscle formation and functions, bone and teeth building and formation, the heart and digestive systems, and blood cell formation. Potassium is important in metabolic processes, such as maintaining water balance in a cell unit. Iodine is a component of endocrine system. On their own, they are part of many organic molecules. Minerals are the basis of important digestive fluids, such as hydrochloric acid. The important minerals in the human body are calcium, phosphorus, potassium, chromium, sodium, chlorine, sulfur, copper, magnesium, manganese, molybdenum, iron, iodine, zinc, and selenium [Otten, Helwig, and Meyers 2006].

The amount of mineral the body needs divides the spectrum of minerals into macro minerals, trace minerals, and ultra trace minerals. Calcium, phosphorus (phosphates), sulfur, sodium, potassium, chloride, and magnesium are required in the amount of 100 mg and more. They are called macro minerals.

The minerals required in much smaller amounts, such as 15 mg/day, are iron, iodine, chromium, molybdenum, copper, manganese, selenium, and zinc. These are called trace minerals. Ultra trace minerals are needed in extremely small quantities, such as micrograms; they are arsenic, boron, nickel, silicon, and vanadium. They have been shown to play a role in experimental animals, but sufficient data for humans are lacking. Many factors influence the absorption of minerals in the body. Fiber and phytates from plant source are a hindrance in absorption. The quantity of minerals present in food is dependent on the composition of soil and water, in which the food is grown.
CALCIUM

Calcium is an essential mineral that is the most common and abundant in the body. Calcium balance in humans is very important and turns out to be positive during growth, becomes steady in mature adults, and declines in the elderly [CDC 2008; Mason 2008; Jelin et al. 2008].

Mechanism of Action

Calcium plays a major role in skeletal muscle formation and functions, bone and teeth building and formation, the heart and digestive systems, and blood cell formation. It is highly concentrated in bones and teeth in an amount in excess of 99% of calcium that exists in the human body [Mason 2007; “Calcium, Copper” 2008; Jelin et al. 2008].

Absorption

Calcium is primarily absorbed in the small intestine of the gut involving an active process with the help of vitamin D. Absorption of calcium in general is low and can be increased with intake of food [Mason 2007]. Several factors affect the absorption of calcium, which may include age, environmental conditions, race, and dietary status. Aging decreases the ability to absorb calcium, resulting in negative calcium balance and bone loss [Pattanaungkul et al. 2000; Heaney 2001]. It is also known that Asians and Africans tend to have higher calcium absorption properties than Caucasians [Celotti and Bignamini 1999]. Weight loss has been linked to decrease in calcium absorption, which significantly affects bone loss. Absorption also tends to be optimal in conditions of high requirement of calcium, such as in childhood, adolescence, pregnancy, and breastfeeding [Mason 2007].

Distribution

Approximately 50% of the serum calcium is in a bound form to plasma proteins. Calcium is converted to an active free ionized form in the blood. The freely available calcium is used as an indicator for calcium levels in humans [Power et al. 1999; Jelin et al. 2008]. However, about 99% of body calcium is stored in bones and teeth [Mason 2007].

Elimination

Calcium is eliminated from the human body via various routes. These routes include feces, urine, sweat, skins cells, and breast milk. Feces serve as the main route of elimination for unabsorbed and secreted calcium [Mason 2007; Jelin et al. 2008].
Bioavailability

Bioavailability of calcium in the body depends highly on absorption. Absorption may be reduced by certain food such as high-fiber cereal, spinach, and cauliflower. It has also been documented that high sodium-containing food may reduce calcium retention in the body [Mason 2008].

Uses

There are many uses for calcium based on several studies conducted in humans and animals [Mason 2007; “Calcium, Copper” 2008]. Calcium may play a significant role in bone loss prevention, calcium deficiency, cardiopulmonary resuscitation, high blood phosphorus level, osteoporosis, high blood potassium level, and high blood pressure [“Calcium, Copper” 2008; Jelin et al. 2008].

Dietary Sources

Several dietary types have been documented to be rich in calcium. Selected examples of these food types include cereal products, milk and dairy products, fish, fruits, vegetables, and nuts. These groups of food represent the major sources of dietary calcium [Mason 2007].

Commercial Preparations

Calcium is available in various salt forms. The normal recommended daily dose for adults range from 400 to 3,000 mg as documented in various studies. However, different doses may be required for certain conditions; therefore, it is highly recommended to seek advice from a healthcare provider for dosing recommendations [Mason 2007; “Calcium, Copper” 2008]. To cite an example, the recommended dose for the prevention of osteoporosis is 1,000–1,200 mg daily [Mason 2007].

Deficiency

The major problem with calcium deficiency may lead to reduction of peak bone mass and mineral content [Mason 2007].

Adverse Effects, Contraindications, and Interactions

Common adverse effects associated with the use of calcium include abdominal pain, elevated calcium in the blood, confusion, dry mouth, frequent urination, kidney stones, nausea, thirst, and vomiting [“Calcium, Copper” 2008]. Calcium supplements should not be considered in certain conditions, such as high levels of calcium in the blood and in the urine as well as patients with chronic kidney diseases [Mason 2007]. Calcium can interact with various medicines, such as antacids, seizure medications,
blood pressure medicines, cholesterol medications, diuretics, thyroid medicines, and weight loss products [“Calcium, Copper” 2008]

CHROMIUM

Chromium plays a role in the body’s use of energy-providing carbohydrates, proteins, and fats. Short supply of chromium is associated with impaired glucose tolerance and diabetes-like symptoms [Glinsmann and Mertz 1966]. A chromium diabetes link was discovered when severe diabetic symptoms of a long-term tube-fed patient were alleviated by supplemental chromium [Jeejeebhoy et al. 1977).

Mechanism of Action

Chromium is an essential trace element. Metallic chromium has no biological activity. Chromium is referred to as a glucose tolerance factor. This glucose tolerance factor is a complex of molecules. Glycine, cysteine, glutamic acid, and nicotinic acid, along with chromium, form this complex [Jelin et al. 2008].

Absorption

The commonly available salts of chromium are chromium chloride, chromium picolinate, and chromium polynicotinate. Chromium picolinate at 4% is a more absorbed salt form than chromium chloride [Anderson et al. 1997]. The low absorption percentage, which decreases further when intake is increased, may be part of the reason chromium is not toxic. Chromium absorption can increase with exercise [Otten, Helwig, and Meyers 2006].

Distribution

Chromium is stored in the liver, spleen, soft tissues, and bone [Otten, Helwig, and Meyers 2006].

Elimination

Most absorbed chromium is excreted rapidly in the urine, whereas unabsorbed chromium is excreted through feces [Otten, Helwig, and Meyers 2006].

Bioavailability

The optimum solubility of chromium compounds is achieved at stomach pH [Otten, Helwig, and Meyers 2006]. Vitamin C enhances absorption of chromium [Jelin et al. 2008]. Urinary chromium excretion is related to the insulinogenic properties of the carbohydrates. Thus, diets high in simple sugars are likely to influence chromium absorption negatively [Otten, Helwig, and Meyers 2006].

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Uses

Some diabetes studies have shown that chromium supplementation has a beneficial effect on plasma lipids, although study results have been far from uniform. In one study, total cholesterol was significantly reduced in the group receiving the higher dose of chromium [Anderson et al. 1997]. It has been documented in clinical studies that triglyceride levels in people with type II diabetes who took chromium supplements were lowered significantly [Lee and Reasner 1994].

Dietary Sources

Natural food supply is rich in chromium content. Geochemical factors determine the chromium content in food. Refining processes deplete chromium content from foods such as cereal and grains. Rich sources of chromium include beef, black strap molasses, brewer’s yeast, brown rice, calves’ liver, unrefined cereals, chicken, corn, dairy products, dried beans, and pulses [Otten, Helwig, and Meyers 2006].

Interactions and Side Effects

Vitamin C may enhance the absorption of chromium. Simple sugars and phytates decrease chromium absorption [Otten, Helwig, and Meyers 2006].

COPPER

Copper is a type of mineral that occurs in many foods and plays numerous roles in the human body [Mason 2007].

Mechanism of Action

Copper is known to play a significant role in bone formation, connective tissues integrity, iron absorption, synthesis of hemoglobin, and metabolic pathways, including glucose and cholesterol [Mason 2007].

Absorption

Absorption of copper occurs primarily in the small intestine and to a very small extent in the stomach. Normally, absorption occurs with a concentration gradient with higher intake of copper and an alternative mechanism at a lower level of intake [Mason 2007].

Distribution

The liver serves as major organ in uptake, transport, and storage of copper in the body [Mason 2007].
Elimination

Copper can be eliminated via various routes, with a major emphasis on bile and feces. Excretion via the urine and sweat serve as routes of elimination to a small extent [Mason 2007].

Bioavailability

High-fiber-containing food can reduce absorption of copper, which can ultimately lower bioavailability of copper in the body. This is not the case with the daily recommended dietary intake of fiber-containing foods [Mason 2007].

Uses

There is a claim that copper plays a protective role against high cholesterol levels. However, results of studies in humans are inconclusive [Mason 2007]. The primary use of copper is for copper deficiency [Pattanaungkul et al. 2000].

Deficiency

Copper deficiency is rare; however, when it occurs, it may lead to conditions such as anemia and immune system impairment [Mason 2007].

Dietary Sources

Food types such as cereal, meat, vegetables, fruits, nuts, and plain chocolate are known to provide major sources of copper in the body [Mason 2007].

Commercial Preparations

The benefits of using copper supplements have not been proven in studies [Mason 2007]. However, supplements do exist and may be available in dosage forms such as tablets and capsules. It is important to acknowledge that copper supplements are usually part of multivitamin and mineral preparations on the market. The most commonly available salts of copper are copper amino acid chelate, copper gluconate, and copper sulfate without any specific dosing requirements [Mason 2007]. However, for adults, a maximum dose of 10,000 μg daily has been recommended as the RDA [“Calcium, Copper” 2008].

Adverse Effects, Contraindications, and Interactions

Higher doses of copper may cause problems such as nausea, vomiting, diarrhea, low blood pressure, and back pain. Abdominal pain, fatigue, and infection are additional side effects that have been documented. Copper does interact with many drugs, including oral contraceptives, penicillamine, seizure drugs, and antacids [Mason 2007; “Calcium, Copper” 2008].
IODINE

Iodine is an essential element in the human body. Its primary function involves thyroid function. Deficiency has been associated with many health issues, including thyroid malfunctioning, skin problems, and neurological problems [“Calcium, Copper” 2008].

Mechanism of Action

Iodine is a major component of the thyroid hormones and is important for many functions, including enzyme activities and protein regulation [Otten, Helwig, and Meyers 2006].

Absorption

Iodine undergoes a process known as reduction to a reduced form known as iodide in the gut for easy absorption. Absorption can be greatly reduced by soya flour, which is found in some infant formula [Otten, Helwig, and Meyers 2006].

Distribution

Once iodine is absorbed, it is freely taken up by certain organs, such as the thyroid and the kidney. The thyroid gland uses the absorbed iodide for thyroid hormone synthesis, whereas the rest get eliminated via urine [Otten, Helwig, and Meyers 2006].

Elimination

The primary elimination route of iodine is through the urine [Otten, Helwig, and Meyers 2006].

Bioavailability

Bioavailability of iodine is enhanced by the complete absorption of the mineral [Otten, Helwig, and Meyers 2006; Mason 2007].

Uses

Iodine is useful in many conditions; however, the most important ones are goiter, iodine deficiency prevention, skin disinfectant, water purification, infection prevention, hearing loss, and Grave’s disease [“Calcium, Copper” 2008].

Deficiency

Deficiency has been associated with numerous health conditions, such as intestinal problems, neurological issues, and skin problems. It can be very serious
in pregnant and nursing mothers, resulting in neurocognitive disorders in infants. Severe deficiency has been associated with conditions such as goiter in adults and cognitive developmental issues in children [Otten, Helwig, and Meyers 2006; “Calcium, Copper” 2008].

**Dietary Sources**

Salt represents the most important source of iodine. Higher concentration of iodine usually comes from seafood [Otten, Helwig, and Meyers 2006].

**Commercial Preparations**

Lugol solution, saturated solution of potassium iodide, povidone-iodine, and sodium iodide are examples of iodine preparations [“Calcium, Copper” 2008].

Recommended daily dosing for adults ranges from 150 to 290 mcg (breastfeeding women) and ranges from 50 to 900 mcg depending on the age group [“Calcium, Copper” 2008].

**Adverse Effects, Contraindications, and Interactions**

Common side effects that have been associated with iodine use or exposure, including skin lesions, confusion, cough, depression, diarrhea, muscle aches, numbness, unpleasant taste, and weakness [“Calcium, Copper” 2008]. Iodine-based products should be avoided for patients with known hypersensitivity or allergy to those products. Iodine may interact with several medications, such as Amiodarone, antithyroid medications, lithium, diuretics, and high blood pressure drugs commonly described as angiotensin-converting enzyme inhibitors. Additionally, certain food types have been known to interact with iodine. These include cabbage, legumes, cassava, herbs, and supplements with identical effects [“Calcium, Copper” 2008].

**IRON**

Iron is an essential mineral that is relevant for transport of oxygen for metabolic pathways in the human body [“Calcium, Copper” 2008]. It is found in two different forms in the body: a reduced state (ferrous iron) and an oxidized form (ferric iron) [Jelin et al. 2008].

**Mechanism of Action**

Iron is involved in a number of metabolic pathways, and it is the main component of hemoglobin, myoglobin, and many enzymes. It also plays a major role in the transport and storage of oxygen and DNA synthesis [Mason 2007; “Calcium, Copper” 2008; Jelin et al. 2008].
Absorption

Iron is absorbed in the small intestine primarily in the duodenum and proximal jejunum, with hemoglobin iron-containing products more easily absorbed than the non-hemoglobin-containing products. Absorptions is the primarily determinant of how iron content is regulated in the human body [Whitney, Cataldo, and Rolfes 1998; Panel on Micronutrients et al. 2002; Mason 2007; National Collegiate Athletic Association 2007; Jelin et al. 2008].

Distribution

Iron is normally bound to blood proteins, referred to as transferring. Once absorbed and transported, it is normally stored in organs such as the spleen, liver, and bone marrow [Mason 2007].

Elimination

Elimination of iron in the body is very limited and can easily build up in the body to toxic levels. A very small fraction is eliminated via the feces, urine, skin, sweat, as well as hair and nails. Also, during the menstrual cycle, there is some loss of iron in the menstrual blood [Mason 2007; Jelin et al. 2008].

Bioavailability

The bioavailability of hemoglobin-containing iron is increased when taken together with certain foods, such as meat, poultry, and fish [Mason 2007].

Uses

The primary function of iron is to combat anemia. Iron deficiency has been associated with chronic diseases, pregnancy, and menstruation in the general population ["Calcium, Copper” 2008]. It has been found to be useful in minimizing attention deficit-hyperactivity disorder (ADHD), canker sores, depression, and fatigue [Jelin et al. 2008]. The usual dose for the treatment of iron deficiency anemia is up to 300 mg daily of elemental iron [Jelin et al. 2008].

Deficiency

Uncontrolled iron deficiency may lead to microcytic hypochromic anemia, which is a very serious condition clinically, the symptoms of which include fatigue and weakness. Mental retardation and growth or developmental abnormalities have been associated with iodine deficiency. Learning disability has also been linked to iodine deficiency [Otten, Helwig, and Meyers 2006; Mason 2007].
Dietary Sources

Certain types of food are documented to be rich in iron. These include cereal products, eggs, meat, nuts, fruits, and vegetables [Mason 2007].

Commercial Preparations

There are various salt forms of iron. These include ferrous fumarate, gluconate, glycine sulfate, orotate, succinate, and sulfate. The daily normal dose as a supplement is about 10–17 mg [Mason 2007]. For iron deficiency anemia in adults, the normal recommended dose is 50–100 mg of elemental iron given in divided doses three times daily [Jelin et al. 2008; McEvoy 2008].

Adverse Effects, Contraindications, and Interactions

The most significant adverse effects seen with intake of iron supplements are nausea and constipation, which can be serious in elderly people [Panel on Micronutrients et al. 2002; Mason 2007; Jelin et al. 2008]. The most common side effects associated with iron or iron intake include, but are not limited to, abdominal pain, joint pain, death, constipation, fatigue, shortness of breath, and vomiting [“Calcium, Copper” 2008]. Individuals with known hypersensitivity or allergy to iron should be cautious about iron-containing products and should avoid it if at all possible. Conditions such as kidney diseases, pancreatitis, and peptic ulcer diseases warrant avoidance of iron supplements [“Calcium, Copper” 2008]. Certain drugs, such as antacids, quinolones, and tetracyclines, among others, can interact with iron-containing products or supplements [Mason 2007]. Zinc can impede iron absorption when taken on an empty stomach [Jelin et al. 2008].

MAGNESIUM

Magnesium is another trace element found in the human body [Mason 2007].

Mechanism of Action

Magnesium is an important mineral required for RNA and DNA synthesis and calcium metabolism [Mason 2007].

Absorption

Magnesium is absorbed primarily in the small intestine by both active process and diffusion. Absorption decreases with increasing intake of magnesium [Mason 2007; Jelin et al. 2008].
Distribution

Distribution of magnesium is carried out in both the soft tissues and skeleton.

Elimination

The major elimination route of magnesium is via the kidney in the form of urine and, to some extent, via the stool. Saliva and breast milk also serve as elimination routes for a very small percentage of magnesium excretion [Mason 2007].

Bioavailability

Bioavailability of magnesium can be greatly increased by vitamin D. Fiber-containing products or foods decrease bioavailability of magnesium [Otten, Helwig, and Meyers 2006].

Uses

The main function or use of magnesium is for the prevention of low levels of magnesium and as a laxative. It has been used in the management of asthma and seasonal allergies and useful in the treatment of ADHD [Jelin et al. 2008]. Magnesium may play a role in certain diseases such as hypertension, diabetes, migraine headaches, osteoporosis, premenstrual syndrome, and normal bone structure [Mason 2007; Jelin et al. 2008].

Deficiency

The following conditions have been documented as clinical signs and symptoms of magnesium deficiency: low calcium and potassium levels, muscle spasm, tremor, lethargy, apathy, convulsions, coma, anorexia, nausea, vomiting, abdominal pain, intestinal paralysis, arrhythmias, tachycardia, and sudden death with cardiovascular origin [Mason 2007].

Dietary Sources

Foods rich in magnesium include cereals, milk, dairy products, meat, fish, vegetables, fruits, and nuts. High-fiber-containing foods provide high sources of magnesium [Mason 2007; Jelin et al. 2008].

Magnesium supplements are available in two main dosage forms, tablets and capsules. It can also be found in combination with calcium supplement or with vitamin D. The daily dose has not been decided yet in the literature [Mason 2007]. However, a dose of 350 mg/day can be taken without any safety issues [Jelin et al. 2008]. Examples of commercial preparations are magnesium chloride (Slo-Mag), magnesium lactate (Mag-Tab SR), and magnesium oxide (Magox) [Jelin et al. 2008]
Adverse Effects, Contraindications, and Interactions

Magnesium is fairly safe and may only pose a problem in individuals with renal or kidney insufficiency. Magnesium has been associated with nausea, vomiting, and diarrhea [Jelin et al. 2008]. It is known to cause cathartic effect at a certain dose, normally ranging between 3 and 5 g of magnesium [Mason 2007]. Alcohol, diuretics, quinolone antibiotics such as ciprofloxacin, and tetracyclines may interact with magnesium, and caution should be exercised when using these combinations [Mason 2007]. As an example, the diuretics may enhance excretion of the magnesium from the body, whereas the antibiotics may significantly reduce absorption of magnesium in the small intestine [Mason 2007]. It does interact with some herbal products and supplements, such as boron, calcium, malic acid, vitamin D, and zinc [Jelin et al. 2008].

MANGANESE

Manganese is another essential trace mineral [Mason 2007].

Mechanism of Action

Manganese is involved in several metabolic pathways involving several enzymes. It is also known to regulate glucose and calcium activities in the body [Mason 2007; Jelin et al. 2008].

Absorption

Absorption is known to take place in the entire small intestine. Normally, the absorption of manganese is not very efficient and is actually considered poor [Mason 2007].

Distribution

Manganese is distributed in the blood primarily bound to plasma proteins and distributed into several organs in the body, including the liver, kidney, pancreas, and the bones [Mason 2007].

Elimination

The main elimination route of manganese is through the feces [Mason 2007].

Bioavailability

Vitamin C and meat are known to increase the bioavailability of manganese. Conversely, iron or iron-containing products and a fiber diet decrease the bioavailability of manganese [Mason 2007].
Uses

It is documented with limited scientific evidence that manganese is useful in certain conditions, such as diabetes. Also, a manganese supplement is known to help treat arthritis conditions [Mason 2007]. It is used for the treatment and prevention of deficiency of manganese, anemia, osteoporosis, and premenstrual syndrome [Jelin et al. 2008].

Deficiency

Weight loss, high cholesterol levels, inflammation of the skin, hair and nail growth retardation, and hair discoloration can be caused by deficiency of manganese [Mason 2007].

Dietary Sources

Dietary sources of manganese come from the usual diets, such as cereal products, milk and dairy products, meat and fish, vegetables, and fruits [Mason 2007].

Adverse Effects, Contraindications, and Interactions

Manganese is very safe when taken orally and has not been associated with any side effects. Chronic inhalation of manganese has associated with toxic reactions in the body. However, this usually occurs in individuals that work in mines and close to industrial plants with a higher tendency to inhale large amounts of manganese [Mason 2007]. There are no interactions reported with manganese [Mason 2007]. However, it found that manganese can interact with calcium, iron, zinc, and certain antibiotics, such as quinolones and tetracyclines [Jelin et al. 2008].

MOLYBDENUM

Molybdenum is an essential trace element for virtually all life forms. It is an important cofactor for a number of enzymes that catalyze important chemical transformations in the carbon, nitrogen, and sulfur cycles [Wuebbens et al. 2000]. Thus, molybdenum-dependent enzymes are required for human health and very interrelated ecosystems. Molybdenum is a trace mineral that plays a role in some anemic conditions, dental caries prevention, and tumor restricting [Wuebbens et al. 2000].

Mechanism of Action

Molybdenum functions as a cofactor for several enzymes, such as sulfite oxidase, xanthine oxidase, and aldehyde oxidase [Otten, Helwig, and Meyers 2006].
Molybdenum functions as an electron carrier in those enzymes that catalyse the reduction of nitrogen and nitrate [Turnlund et al. 1995].

**Absorption**

In a highly efficient way, the dietary molybdenum is utilized in the body. The mechanism of the action is a passive diffusion process. The gastrointestinal tract readily absorbs soluble, but not insoluble, molybdenum compounds. Absorption rate of molybdenum from the diet of both patients and healthy volunteers averaged about 50% in one study and 88–93% in another study [Wester 1971].

**Distribution**

Molybdenum is transported in the blood, is loosely attached to erythrocytes, and binds specifically alpha macroglobulin. The highest concentrations are found in the liver and kidney [Mason 2007].

**Elimination**

Excretion is primarily achieved through the urine and is directly related to the dietary intake [Turnlund et al. 1999].

**Dietary Sources**

Legumes, grain products, and nuts grown in molybdenum-rich soil are primary sources of dietary molybdenum. Animal products, fruits, and vegetables do not contribute much toward the molybdenum content of diet [American Society 2007; Mason 2007].

**Bioavailability**

Like most minerals, molybdenum is less absorbed from soy than other food sources [CDC 2008].

**Uses**

Molybdenum has been found to prevent dental caries in children because of its cariostatic effect [International Molybdenum Association 2002].

**Interactions and Side Effects**

There are no reported side effects and interactions of molybdenum. One reason for this can be the rapid excretion from urine [Otten, Helwig, and Meyers 2006]. Molybdenum is present in most biological forms [Panel on Micronutrients et al. 2002]. During inborn, errors of metabolism of molybdenum, a genetic defect,
prevents sulfi te oxidase synthesis. Because of this, in nonconversion of sulfi te to sulfate, severe neurological damage leading to early death occurs in infants [Otten, Helwig, and Meyers 2006].

PHOSPHORUS

The active form of phosphorus is found in bones and teeth as phosphates. Bones contain the highest amount of phosphorus, about 85%. It is involved in various metabolic pathways [Food and Nutrition 2002; Otten, Helwig, and Meyers 2006].

Mechanism of Action

The primary function of phosphorus is to maintain normal pH. In addition, it is responsible for storage and energy distribution in the body. It is also known to play a role by activating certain proteins through a mechanism referred to as phosphorylation [Otten, Helwig, and Meyers 2006].

Structurally, phosphorus occurs as phospholipids, which are a major component of most biological membranes [Otten, Helwig, and Meyers 2006].

Absorption

Phosphorus can be found in different food items, both organic and inorganic, in a form of phosphate. Inorganic phosphates therefore represent the most common form of phosphorus that is normally absorbed via concentration gradient [Otten, Helwig, and Meyers 2006].

Elimination

Excretion of endogenous phosphorus is mainly through the kidneys. In healthy adults, urine phosphorus is essentially equal to absorbed dietary phosphorus. Smaller amounts of phosphorus are lost in shedding of cells of skin and intestinal mucosa [Otten, Helwig, and Meyers 2006].

Bioavailability

Food such as beans, cereals, and nuts are rich sources of phosphorus. Certain whole-grain foods tend to have higher phosphorus bioavailability, as well as human milk for infants [Otten, Helwig, and Meyers 2006].

Uses

Athletes sometimes use phosphate supplements because phosphorus supports tissue growth [Healthnotes 2004].
Deficiency

Phosphorus deficiency is rare because of its abundance in various foods. Refeeding of energy-depleted individuals, either orally or parenterally, without adequate attention to supplying phosphorus can precipitate extreme, even fatal, hypophosphatemia. Such outcomes can occur on recovery from alcoholic bouts or from diabetic ketoacidosis [Panel on Micronutrients et al. 2002; Knochel et al. 2006].

Dietary Sources

Nuts, seeds, fish, and poultry are good sources of dietary phosphorus. Phosphates are found in naturally occurring foods and as food additives in the form of various phosphate salts. These salts are used in processed foods for moisture retention, smoothness, and binding [Otten, Helwig, and Meyers 2006].

Adverse Effects

Higher levels of phosphates can lead to calcification in nonskeletal tissues, leading to organ damage. Because kidneys are very efficient in excreting phosphorus, this is not seen in healthy individuals. Hyperphosphatemia has occurred as a result of increased intestinal absorption of phosphate salts taken by mouth as well as a result of colonic absorption of the phosphate salts in enemas [Knochel et al. 2006].

Interactions

Pharmacological doses of calcium carbonate may interfere with phosphorus absorption. When taken in large doses from antacids, aluminum may interfere with phosphorus absorption [Otten, Helwig, and Meyers 2006].

POTASSIUM

The mineral potassium is the main intracellular cation in the body. Potassium is an essential dietary mineral and electrolyte. Normal body function depends on tight regulation of potassium concentrations both inside and outside of cells [Peterson 1997]. It also plays a key role in cardiac, skeletal, and smooth muscle contraction, making it an important nutrient for normal heart, digestive, and muscular function. A diet high in potassium from fruits, vegetables, and legumes is generally recommended for optimum heart health [Otten, Helwig, and Meyers 2006].

Mechanism of Action

Potassium is the principal intracellular cation. It is fundamental to the regulation of acid base and water balance [Sheng 2000; Jelin et al. 2008].
Absorption

The small intestine is the main site of absorption of potassium [Mason 2007]. In a healthy population, about 80–85% of the dietary potassium is absorbed. As insulin stimulates the sodium-potassium ATPase pump, insulin concentration can affect extracellular as well as plasma concentration of potassium [Otten, Helwig, and Meyers 2006].

Distribution

Potassium is present in the form of a cation intracellular fluid, whereas sodium is the principal cation in extracellular fluid. Potassium concentrations are about 30 times higher inside than outside cells, whereas sodium concentrations are more than 10 times lower inside than outside cells [Sheng 2000].

Elimination

The relation between dietary potassium intake and urinary potassium content is high. Excretion is mainly via urine. Kidneys cannot conserve potassium. The rest of the unabsorbed potassium is excreted through feces and a smaller amount in sweat [Otten, Helwig, and Meyers 2006].

Bioavailability

Because of the high water solubility of potassium, its absorption is very efficient. There is limited information about the bioavailability from individual foods, because it is well absorbed from most of the foods [Otten, Helwig, and Meyers 2006].

Deficiency

Potassium deficiency is uncommon because of its natural abundance, unless there is restricted food intake. African Americans normally would benefit from increased potassium intake because of their sodium sensitivity [Otten, Helwig, and Meyers 2006].

Dietary Sources

Fruits and vegetables are good sources of potassium [Otten, Helwig, and Meyers 2006].

Adverse Effects and Interactions

In healthy individuals, food alone cannot cause potassium excess. However, supplements can be responsible for acute toxicity in healthy individuals. Cardiac
arrhythmias and gastrointestinal discomfort are results of excess potassium intakes [Otten, Helwig, and Meyers 2006].

SELENIUM

Introduction

Selenium is an essential trace element, and it is also an antioxidant nutrient involved in the defense of the body from oxidative stress [Mason 2007]. Humans and animals require selenium for the function of a number of selenium-dependent enzymes that are essential in many metabolic functions in the body [Rayman 2000].

Mechanism of Action

During selenoprotein synthesis, selenocysteine is incorporated into a very specific location in the amino acid sequence to form a functioning protein. However, when selenium is present in the soil, plants incorporate it into compounds that contain sulfur [Rayman 2000].

Absorption

Most dietary selenium is in the form of selenomethionine or selenocysteine. Both these forms are well absorbed. Other forms of selenium include selenate and selenite, commonly found in supplements and fortified foods. Selenium is destroyed when foods are refined or processed. Selenium in general is known to be well absorbed after intake; however, a significant amount is known to be eliminated in the urine [Otten, Helwig, and Meyers 2006].

Distribution

Two pools of reserve selenium are present in the body. The first is selenomethionine, which may have a similar function as methionine. The second reserve pool is the selenium found in liver glutathione [Otten, Helwig, and Meyers 2006].

Elimination

Selenite, selenate, and selenocysteine are metabolized to selenide in the body. These selenides can be metabolized further or be converted to excretory metabolite. Selenium is excreted through urine [Otten, Helwig, and Meyers 2006].

Bioavailability

Bioavailability of selenium from animal sources, and particularly fish, is comparable with plant sources such as yeast. Bioavailability from fortified foods is lower than natural sources [Otten, Helwig, and Meyers 2006].
Uses

Selenium can possibly be used in cancer prevention. Selenium supplementation can increase sperm motility. Selenium has been found to have a positive effect on mood swings in some individuals. Patients with asthma, decreased immune function, and HIV infection may benefit from selenium supplements [Mason 2007].

Deficiency

Insufficient selenium intake results in decreased activity of certain enzymes that are responsible for antioxidant activities in the body, such as glutathione peroxidases, thioredoxin reductase, and thyroid deiodinases. Obvious clinical illness is rare with selenium deficiency, even in a more severe form. However, selenium-deficient individuals appear to be more susceptible to additional physiological stresses. Muscle pain and tenderness have both been associated with selenium deficiency [Burk and Levander 1999; Mason 2007].

Dietary Sources

Selenium content of the food greatly depends on the soil in which the animal was raised or the plant was grown. The richest food sources of selenium are organ meats and seafood, followed by muscle meats. Brazil nuts grown in areas of Brazil with selenium-rich soil may provide more than 100 mcg of selenium in one nut, whereas those grown in selenium-poor soil may provide 10 times less [Chang 1995].

Commercial Preparations

Selenium supplements are available in several forms. Sodium selenite and sodium selenate are inorganic forms of selenium, whereas selenomethionine represents the organic form, which is rich in most naturally occurring food [Panel on Dietary Antioxidants and Related Compounds et al. 2000].

Adverse Effects

High doses of selenium can be toxic. Acute and fatal toxicities have occurred with accidental or suicidal ingestion of gram quantities of selenium. Chronic selenium toxicity (selenosis) may occur with smaller doses of selenium over long periods of time. Hair and nail brittleness are known to be common in selenium toxicity. Gastrointestinal problems, skin rashes, garlic breath odor, fatigue, irritability, and nervous system problems have also been reported with selenium toxicity [Panel on Dietary Antioxidants and Related Compounds et al. 2000].

Interactions

There are no known food interactions affecting absorption and usage of selenium [Jelin et al. 2008]. Limited information is currently found on interaction between...
selenium and medications. Medications such as valproic acid have been found to decrease selenium levels [Flodin 1990]. Clozapine, an antipsychotic drug, has also been found to decrease selenium levels [Mason 2007].

The efficacy of cholesterol-lowering agents, such as simvastatin and niacin, has been reduced when used in conjunction with beta-carotene, vitamin C, vitamin E, and selenium [Jelin et al. 2008].

**ZINC**

Zinc is an essential trace element throughout the life process [Mason 2007].

**Mechanism of Action**

Zinc is the second most prevalent trace element in the body. It is known that the cell nucleus contains about 30% of zinc. It acts as a cofactor in many biological activities that take place in the body such as DNA, RNA, and protein synthesis in general [Jelin et al. 2008].

**Absorption**

The small intestine, particularly jejunum, acts as the most effective zinc absorption site. Zinc deficiency enhances absorption [Otten, Helwig, and Meyers 2006; Mason 2007; Jelin et al. 2008].

**Distribution**

Zinc is well distributed, and more than 85% is stored in skeletal muscle and bone. Other zinc storage tissues include the liver, kidney, pancreas, prostate gland, and retina [Otten, Helwig, and Meyers 2006; Mason 2007].

**Elimination**

Zinc is eliminated mainly through feces. Starvation and trauma tend to increase zinc losses through urine. Skin cell shedding, sweat, hair, semen, and menstruation are the other means of zinc loss through the body [Otten, Helwig, and Meyers 2006].

**Bioavailability**

Absorption of zinc can be impaired by phytate and calcium, whereas proteins have positive impact on zinc absorption [Lonnerdal 2000].

**Uses**

A zinc supplement is indicated for treatment and prevention of its deficiency. It can also be used for managing the common cold, recurrent ear infection, and respiratory infection [Jelin et al. 2008].
Deficiency

There is a broad range of physiological signs of zinc deficiency because of the multiple biological functions and multiple distribution sites in tissues. Clinical signs of frank zinc deficiency may be seen in skin problems such as inflammation [Van Wouwe 1989]. Diarrhea, impaired cognitive, behavioral problems, impaired memory, learning disability, and neuronal atrophy can be seen in infants as indications of zinc deficiency [Hambidge 1986]. Zinc deficiency in pregnancy can lead to growth retardation in the unborn baby in addition to conditions such as congenital abnormalities in fetus [Mason 2007].

Dietary Sources

Zinc occurs in a wide variety of foods but is found in highest concentrations in animal sources, particularly in red meat and seafood. Whole grains contain more zinc than refined grains [Otten, Helwig, and Meyers 2006].

Adverse Effects

High intakes of zinc are possible either through supplemental zinc or by contact with environmental zinc. Toxicity symptoms, such as nausea, vomiting, epigastric pain, diarrhea, and lethargy, may occur with acute high intakes [Fosmire 1990].

Interactions

Absorption of copper, iron, and folate can be decreased by zinc. Conversely, zinc absorption may be reduced by phytic acid, fiber, calcium, and phosphates. Protein intake positively affects zinc absorption [Otten, Helwig, and Meyers 2006]

REFERENCES


