

Introduction

Manganese is a mineral element that is both nutritionally essential and potentially toxic. Scientists are still working to understand the diverse effects of manganese deficiency and manganese toxicity in living organisms. Manganese plays an important role in a number of physiologic processes as a constituent of some enzymes and an activator of other enzymes.

Food Sources

Minerals from plant sources may vary from place to place because soil mineral content varies geographically.

Rich sources of manganese include whole grains, nuts, leafy vegetables, and teas. Foods high in phytic acid such as beans, seeds, nuts, whole grains, and soy products or foods high in oxalic acid such as cabbage, spinach, and sweet potatoes, may slightly inhibit manganese absorption. Although teas are rich sources of manganese, the tannins present in tea may moderately reduce the absorption of manganese.

Hazelnuts, almonds, macadamia, cashew, brown rice, chickpea

Inhibitors/stimulators:

The following food components have been found to stimulate the absorption of magnesium.

Calcium – Some evidence exists that calcium lowers manganese bioavailability in healthy adults.

Iron – Some evidence suggest that iron and manganese can share common absorption and transport pathways. Absorption of manganese from a meal is reduced as the meal's iron content is increased.

Magnesium – Supplemental magnesium (200 mg/day) decreased manganese bioavailability slightly, either by decreasing manganese absorption or by increasing its loss in healthy adults.

Functions in the Body

Antioxidant function

Manganese superoxide dismutase (MnSOD) is the principal antioxidant enzyme of mitochondria. Because mitochondria consume over 90% of the oxygen used by cells, they are especially vulnerable to oxidative stress. The superoxide radical is one of the reactive oxygen species produced in mitochondria during ATP synthesis. MnSOD catalyzes the conversion of superoxide radicals to hydrogen peroxide, which can be reduced to water by other antioxidant enzymes.

Metabolism

A number of manganese-activated enzymes play important roles in the metabolism of carbohydrates, amino acids, and cholesterol. Pyruvate carboxylase, a manganese-containing enzyme, and phosphoenolpyruvate carboxykinase (PEPCK), a manganese-activated enzyme, play critical roles in gluconeogenesis — the production of glucose from non-carbohydrate precursors. Arginase, another manganese-containing enzyme, is required by the liver for the urea cycle, a process that detoxifies ammonia generated during amino acid metabolism.

Introduction

Zinc is an essential mineral (and trace element) that is found in almost every cell. It stimulates the activity of approximately 100 enzymes, which are substances that promote biochemical reactions in the human body. Zinc supports a healthy immune system, is needed for wound healing, helps maintain the body's sense of taste and smell, and is needed for DNA synthesis. Zinc also supports normal growth and development during pregnancy, childhood, and adolescence.

Food Sources

Zinc is found in a wide variety of foods. Oysters contain more zinc per serving than any other food. Other good food sources include red meat, poultry, shellfish, beans, nuts, certain seafood, whole grains, fortified breakfast cereals, and dairy products. Zinc absorption is greater from a diet high in animal protein than a diet rich in plant proteins.

Zinc bioavailability (the fraction of zinc retained and used by the body) is relatively high in meat, eggs, and seafood because of the relative absence of compounds that inhibit zinc absorption and the presence of certain amino acids (cysteine and methionine) that improve zinc absorption. Phytates, which are found in whole grain breads, cereals, legumes and other products, can decrease zinc absorption. The zinc in whole grain products and plant proteins is therefore less bioavailable. The enzymatic action of yeast

reduces the level of phytic acid in foods; therefore, leavened whole grain breads have more bioavailable zinc than unleavened whole grain breads.

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Zinc (Zn)



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Introduction











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Some important food sources of zinc:

				
Oysters	Alfalfa	Liver	Pumpkin seeds	Corned beef
				
Roast beef	Lamb	Crab	Pork cutlets	Sardines

Recommended Dietary Allowance (RDA)

The European Union RDA for the general population is set at 15 mg/day.

Because a sensitive indicator of zinc nutritional status is not readily available, the RDA for zinc was based on a number of different indicators of zinc nutritional status and represents the daily intake likely to prevent deficiency in nearly all individuals in a specific age and gender group

Inhibitors/stimulators:

The following food components have been found to stimulate the absorption of zinc.

Cysteine, Methionine – these amino acids increase zinc absorption.

The following food components have been found to inhibit the absorption of zinc.

Phytates – decrease the absorption of zinc.

Iron – High doses of iron supplements taken together with zinc supplements on an empty stomach can inhibit the absorption of zinc. When taken with food, supplemental iron does not appear to inhibit zinc absorption. Iron-fortified foods have no effect on zinc absorption.

This interaction is of concern in the management of iron supplementation during pregnancy and lactation and has led some experts to recommend zinc supplementation for pregnant and lactating women taking more than 60 mg/day of elemental iron.

Calcium – High levels of dietary calcium may possibly impair zinc absorption in humans. Calcium in combination with phytic acid reduces zinc absorption. This effect is particularly relevant to individuals consuming a diet that is highly dependent on tortillas made with lime (calcium oxide)

Functions in the Body

Numerous aspects of cellular metabolism are zinc-dependent. Zinc plays important roles in growth and development, the immune response, neurological function, and reproduction. On the cellular level, the function of zinc can be divided into three categories: 1) catalytic, 2) structural, and 3) regulatory.

Catalytic role of zinc

Nearly 100 different enzymes depend on zinc for their ability to catalyze vital chemical reactions. Zinc-dependent enzymes can be found in all known classes of enzymes.

Structural role of zinc

Zinc plays an important role in the structure of proteins and cell membranes. A finger-like structure, known as a zinc finger motif, stabilizes the structure of a number of proteins. For example, copper provides the catalytic activity for the antioxidant enzyme copper-zinc superoxide dismutase (CuZnSOD), while zinc plays a critical structural role.

The structure and function of cell membranes are also affected by zinc. Loss of zinc from biological membranes increases their susceptibility to oxidative damage and impairs their function.

Regulatory role of zinc

Zinc finger proteins have been found to regulate gene expression by acting as transcription factors (binding to DNA and influencing the transcription of specific genes). Zinc also plays a role in cell signalling and has been found to influence hormone release and nerve impulse transmission. Recently zinc has been found to play a role in apoptosis (gene-directed cell death), a critical cellular regulatory process with implications for growth and development, as well as a number of chronic diseases.

Deficiency

Zinc deficiency at such is rare, but most often occurs when zinc intake is inadequate or poorly absorbed, when there are increased losses of zinc from the body, or when the body's requirement for zinc increases (at 14-16 years). Zinc deficiency contributes to many health problems, which can be very serious if zinc deficiency is severe.

The consequences of zinc deficiency are several and they impact on human health severely. Growth retardation, male hypogonadism, neuro-sensory changes (abnormal dark adaptation and changes in taste acuity), delayed wound healing, abnormal immune functions, and impaired cognitive functions are some of the major effects of human zinc deficiency which are reversible with zinc supplementation. A mild deficiency of zinc in pregnant women is associated with increased maternal morbidity, abnormal taste sensation, prolonged gestation, inefficient labour, atonic bleeding, and increased risks to the foetus.

Toxicity

Zinc toxicity from a normal diet is highly unlikely.

Isolated outbreaks of acute zinc toxicity have occurred as a result of the consumption of food or beverages contaminated with zinc released from galvanized containers. Signs of acute zinc toxicity are abdominal pain, diarrhea, nausea, and vomiting. Single doses of 225 to 450 mg of zinc usually induce vomiting. Milder gastrointestinal distress has been reported at doses of 50 to 150 mg/day of supplemental zinc. Metal fume fever has been reported after the inhalation of zinc oxide fumes. Profuse sweating, weakness, and rapid

breathing may develop within 8 hours of zinc oxide inhalation and persist 12-24 hours after exposure is terminated.

Regulation

Zinc is found in highest concentration in the liver, with lesser amounts found in the pancreas, kidney, and pituitary gland. Zinc absorption occurs primarily in the small intestine. Zinc-binding ligand molecules act to transport zinc across the mucosal cells of the intestine, where it is picked up by albumin molecules for transport to the liver and other organs.

Excess zinc is excreted by the kidneys.

Introduction











Phosphorus is an essential mineral that is required by every cell in the body for normal function. The majority of the phosphorus in the body is found as phosphate (PO_4^{3-}). Approximately 85% of the body's phosphorus is found in bone.

Food Sources

Phosphorus is found in most foods because it is a critical component of all living organisms. Dairy products, meat, and fish are particularly rich sources of phosphorus. Phosphorus is also a component of many polyphosphate food additives, and may be present in most soft drinks as phosphoric acid.

The phosphorus in all plant seeds (beans, peas, cereals, and nuts) is present in a storage form of phosphate called phytic acid or phytate. Only about 50% of the phosphorus from phytate is available to humans because we lack the enzymes (phytases) that liberate it from phytate. Yeasts possess phytases, so whole grains incorporated into leavened breads have more bioavailable phosphorus than whole grains incorporated into breakfast cereals or flat breads. The phosphorus content in plant sources may vary from place to place because soil mineral content varies geographically.

Some important food sources of phosphorus:

				
Shrimp	Meat	Cheese	Crab	Mussels
				
Salmon	Liver	Milk	Beans	Nuts

Recommended Dietary Allowance (RDA)

The European Union RDA for the general population is set at 800 mg/day.

Inhibitors/stimulators:

The following food components have been found to stimulate the absorption of phosphorus:

Calcium and Vitamin D – Dietary phosphorus is readily absorbed in the small intestine, and the kidneys excrete any excess phosphorus absorbed. The regulation of blood calcium and phosphorus levels is interrelated through the actions of parathyroid hormone (PTH) and vitamin D. A slight drop in blood calcium levels (e.g., in the case of inadequate calcium intake) is sensed by the parathyroid glands resulting in their increased secretion of PTH. PTH stimulates increased conversion of vitamin D to its active form (1,25-dihydroxycholecalciferol, calcitriol) in the kidneys. Increased calcitriol levels result in increased intestinal absorption of both calcium and phosphorus.

Both PTH and vitamin D stimulate bone resorption, resulting in the release of bone mineral (calcium and phosphate) into the blood. Although PTH stimulation results in decreased urinary excretion of calcium, it results in increased urinary excretion of phosphorus. The increased urinary excretion of phosphorus is advantageous in bringing blood calcium levels up to normal because high blood levels of phosphate suppress the conversion of vitamin D to its active form in the kidneys.

The following food components have been found to inhibit the absorption of phosphorus:

Fructose – some studies have shown that a diet high in fructose (20% of total calories) resulted in increased urinary loss of phosphorus and a negative phosphorus balance.

Functions in the Body

Structure

Phosphorus is a major structural component of bone and teeth in the form of a calcium phosphate salt called hydroxyapatite.

Energy needs

All energy production and storage are dependent on phosphorylated compounds, such as adenosine triphosphate (ATP) and creatine phosphate. When phosphate links to an adenosine diphosphate (ADP) molecule adenosine triphosphate (ATP) is formed, processing a high energy phosphate bond. When broken, this bond releases energy and the phosphate, reforming an ADP molecule. The ATP "energy" molecule is formed during glycolysis and other processes involving the release of chemical energy from food. ATP is used as the primary source of energy for many metabolic and enzymatic activities, especially muscle contraction, active transport, and the formation of DNA.

DNA

Phosphate is an important constituent of RNA and DNA. Nucleic acids (DNA and RNA) responsible for the storage and transmission of genetic information are long chains of phosphate-containing molecule. Phosphate links the individual bases with one another.

Cell wall

Phosphate, from ATP, reacts with choline to initiate synthesis of phospholipids. Phospholipids (e.g., phosphatidylcholine) are major structural components of cell membranes. Phospholipids are instrumental in regulating cellular permeability and are found in the exterior membrane of nerve cells. They are also helpful in solubilising relatively nonsoluble triglycerides and cholesterol.

Hormone and enzyme regulation

A number of enzymes, hormones, and cell signalling molecules depend on phosphorylation for their activation. Phosphorus also helps to maintain normal acid-base balance (pH) in its role as one of the body's most important buffers. The phosphorus-containing molecule 2,3-diphosphoglycerate (2,3-DPG) binds to haemoglobin in red blood cells and affects oxygen delivery to the tissues of the body.

Sodium/potassium pump

The energy released from the high energy phosphate bond of ATP is essential for the operation of the sodium/potassium pump, which exchanges three sodium ions for two potassium ions across a biological membrane. This pump is used to regulate relative amounts of sodium and potassium excreted and retained in the body.

Blood clotting

Adenosine diphosphate, which contains two phosphate molecules, is a constituent of blood platelets and is secreted from platelet granules to stimulate platelet aggregation for blood clotting.

Deficiency

Inadequate phosphorus intake results in abnormally low serum phosphate levels (hypophosphatemia). Because phosphorus is so widespread in food, dietary phosphorus deficiency is usually seen only in cases of near total starvation.

Phosphate deficiencies can be the result defective renal phosphate absorption, as seen in familial vitamin D-resistant rickets, a genetically linked disorder which affects vitamin D utilization. Symptoms are characteristic of other forms of rickets.

Toxicity

The most serious adverse effect of abnormally elevated blood levels of phosphate (hyperphosphatemia) is the calcification of non-skeletal tissues, most commonly the kidneys. Such calcium phosphate deposition can lead to organ damage, especially kidney damage. Because the kidneys are very efficient at eliminating excess phosphate from the circulation, hyperphosphatemia from dietary causes is a problem mainly in people with kidney failure (end-stage renal disease) or hypoparathyroidism. When kidney function is only 20% of normal, even typical levels of dietary phosphorus may lead to hyperphosphatemia. Pronounced hyperphosphatemia has also occurred due to increased intestinal absorption of phosphate salts taken by mouth, as well as due to colonic absorption of the phosphate salts in enemas.