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Mini Review

Micro-Minerals

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Introduction

The global population is on a continuous rise, and the present 7 billion is projected to reach 9.3 billion by 2050 and surpass 10 billion by 2100 [1]. The world's agricultural system needs to produce more than adequate food to meet the current and future demands. Growing required amount of food alone will not solve this predicament but assuring nutritious foods, more importantly, toward a healthy living need to be the priority. Supplementation of macronutrients and micronutrients in a well-balanced proportion is indeed a global challenge. Among the macronutrients and micronutrients, the latter, though required in subtle amounts of micrograms to milligrams per day, plays a vital role on human health. Micronutrients - minerals and vitamins - aid in the normal functioning of human body as they stimulate cellular growth and metabolism by triggering a plethora of chemical reactions. There are 51 micronutrients needed for humans to maintain health but 19 nutrients namely, calcium, phosphorous, magnesium, sulfur, zinc, copper, iron, manganese, chromium, iodine, fluorine, selenium, molybdenum and vitamins A, C, D, E, K and B are considered to be essential for physical and mental development and immune system functioning [2]. The micronutrient malnutrition, also known as hidden hunger, is often overlooked and more than one-third of the current world's population is affected. It is a common contributor to poor growth, intellectual impairment, perinatal complications, increased risk of morbidity and mortality. Incidentally, pregnant women and children below 5 years are at the higher risk of hidden hunger. It is most prevalent in areas where the diet lacks variety, as is the case for many individuals in developing countries [2] but also being observed in developed countries presumably due to increased reliance on processed foods. Among the essential micronutrients, minerals play an indispensable role. These are inorganic nutrients and present in human tissues and fluids. They modulate vital physiochemical processes at the molecular level. They are required in small amounts of less than 1 mg to 2500 mg per day [3]. Herein, properties, critical functions and deficiencies of selected micro-minerals iron, manganese, copper, zinc, chromium and selenium have been discussed along with their predominant food sources and available market foods (Table 1).

Table 1: Comparison of recommended daily intake (RDI) of selected microminerals iron, manganese, copper, zinc, chromium and selenium along with their food sources, few functions and deficiency issues.

Micromineral	RDI	Function	Deficiency	Major source	Natural food	Market food
Iron (Fe^{2+})	15 mg	I. Facilitates transfer of electrons in the respiratory chain and ATP synthesis II. Helps in red blood formation	I. Results in loss of mitochondrial complex in selected regions of the brain II. Causes change in function, morphology, and physiology of the brain III. Diminishes immune function and neuro muscular abnormalities	Meat, legumes, nuts and certain vegetables	Cow pea: 5mg/kg, Dates: 20mg/kg, Berries: 55mg/100g, Wheat bran: 66mg/kg, Lentils: 4-18mg/kg, Broccoli: 7mg/g, Almonds: 34mg/g	Fruit-enriched breakfast cereals: 10.7-13.3mg/100g, Cornflake: 16-63mg/100g, Chocolate donuts: 2.82 mg/100g, Pizza: 1.63 mg/100g, Apple sauce: 23.2mg/kg Milk powder: 1.80mg/kg
Manganese (Mn^{2+})	5 mg	I. Involves in the metabolism of carbohydrates and gluconeogenesis II. Forms the matrices of bones and eggshells	I. Impairs reproductive function in females and testicular degeneration in males II. Decreases levels of clotting proteins and subtle reddening of hair	Cereals, vegetables, tea, coffee and red wine	Cow pea: 27mg/kg, Banana: 3.3mg/kg, Legumes: 10.6mg/kg, Potato: 1.2mg/kg	Sausages: 1.2 mg/kg, Hamburger: 1.09µg/g, Chicken noodle soup: 1.95µg/g, Ketchup: 2.25µg/g, Corn flask: 1.0mg/kg and Multigrain bread: 17mg/kg

Copper (Cu^{2+})	2 mg	I. Involves in iron metabolism	I.Alters the movement of nutrients through cell walls, irregular heartbeat and lowers body temperature	Cereals, fish, meat, poultry, eggs, vegetables and beverages	Millet: 3.83μg/g, White maize: 2.22μg/g, Beef liver: 157 mg/kg Potato:0.48-16.0 mg/kg	Sandwich:0.9 mg/100g, Chocolate:0.64 mg/100g, Ice-cream: 0.17mg/100g Apple sauce:0.184mg/kg
Zinc (Zn^{2+})	15 mg	I. Plays structural role in cellular metabolism II. Protects against accelerating aging and promotes faster recovery from injury	I. Depresses immune functionality Impairs macrophage and neutrophil function II. Inactivates zinc-containing proteins and induces genetic damage	Meat, poultry, eggs, cereals and dairy products	Wheat:1.5-10.2mg/100 g Ripe papaya: 0.39-2.80 mg/100g	Breakfast cereals:0.28 mg/100g, Muffins:1.29mg/100g Chocolates: 0.12mg/100g
Chromium ($Cr3^{+}$)	50-200 mg	I. Escalates insulin action and promotes glucose uptake action by the cells	I. Elevates genes methylation levels in the insulin signaling pathway leading to glucose intolerance II. Causes metabolic symptoms in offspring including obesity, hyperglycemia and hyperinsulinemia	Vegetables, wholegrains, beef, poultry, fruits, milk	Fish: 0.032μg/g; wheat: 0.334μg/g; potato: 0.049μg/g; milk: 0.014mg/g	Cream cheese: 0.011μg/g; Yogurt: 0.021mg/g; Custard: 0.575μg/g
Selenium (Se)	55-70 mg	I. Management of hyperlipidaemia, hyperglycaemia, and hyperphenylalaninemia II. Anticarcinogenic activity, protection against oxidant damage or aging, role in reproduction and detoxicity III. Essential for the metabolic production of thyroid hormone	I.Decreases expression and activity of essential selenoproteins II. Compromises immune and thyroid function and cognitive function III. Increases risks from non-communicable diseases IV. Cardiomyopathy and increased cancer and cardiovascular risk	Nuts, fish, shellfish, red meat, garlic	Brazil nut:12.5mg/kg Fish and shellfish: 0.224-0.567mg/kg Beef: 0.17mg/kg Lamb: 0.14mg/kg Cow milk: 9.6ng/mL Goat milk: 13.3ng/mL	Cheese: 0.07mg/kg; Yoghurt: 0.024mg/kg; Cereals: 43-165 mg/kg

Iron

Iron is a major component of the heme in the hemoglobin (functional iron) and facilitates the transfer of oxygen to tissues and vital organs. Its deficiency is the most common nutritional problem in the world and causes anemia. It is estimated that around 24.8 % of the world's population is affected by anemia, which includes 42% of pregnant women, 30% of nonpregnant women and 47% of preschool children [4].

Manganese

Manganese is found in all tissues and is required for metabolizing amino acids, lipids, proteins and carbohydrates. It plays a key role in immune function, regulation of blood sugar and cellular energy, reproduction, digestion, bone growth, and aids in defense mechanisms against free radicals and in fetal bone formation during organogenesis [5]. Its deficiency impairs growth and induces skeletal abnormalities, ataxia, and abnormal lipid and carbohydrate metabolism [6].

Copper

Copper regulates several enzymes functionality. It stabilizes the walls of blood vessels, strengthens skin, blood vessels, epithelial and connective tissues. Production of color components such as melanin, myelin and hemoglobin as well as thyroid gland functioning are some of its important aspects. Its scarcity results in blood vessel breakage, iron deficiency anemia, osteoporosis and joint problems, brain disturbances, loss of pigment, weakness, fatigue, skin sores and poor thyroid function [7].

Zinc

Zinc is an important mineral with catalytic activity for more than 200 enzymes. It plays a critical role in immune functionality, cell division, protein and DNA synthesis, wound healing, normal growth and development during pregnancy, childhood and adolescence [7]. Low zinc intake appears to be one of the major public health problems especially in adults that results in oxidative damage to DNA. It upturns infection and diarrhea leading to death of about 800,000 children worldwide per year [8].

Chromium

Chromium is crucial for normal maintenance of glucose and lipid metabolism. It aids to preserve RNA configuration and serves as an effective crosslinking agent for collagen [3]. Its functionality is closely tied with insulin and regular consumption decreases insulin requirement [9]. Its paucity impairs lipid and glucide metabolism resulting in high circulating insulin levels leading to vascular lesions, lower HD/LDL ratios and increased levels of atherogenic LDL [10].

Selenium

It is a key cofactor of nearly 50 enzymes. It is critical for converting thyroxine to more active counterpart of triiodothyronine [11]. It is part of the defense system that protects cells from harmful effects of free radicals such as hydrogen peroxide and other peroxides formed by fatty acids [3]. It aids to maintain cell integrity and prevents early fetus mortality due to oxidative damage. Its deficiency leads to Keshan or Kaschin-Beck disease. Keshan disease is a cardiomyopathy and Kaschin-Beck is a disease of cartilage tissue in pre-adolescent and adolescent children, causing osteoarthropathy, joint problems and growth stunting. Low intake of selenium has been associated with increased incidence of cancer, in particular, oesophageal cancer and also with cardiovascular disease [12].

Conclusions

In the era of ever-increasing depletion of microminerals in diets, focused attention to avert micromineral malnutrition is warranted to improve human health. Low cost and sustainable approach of enhancing microminerals amounts in humans could be accomplished through diets fortification but with appropriate consideration on the critical nutritional needs. Functional foods enriched with microminerals, supported through large-scale and long-term research, could indeed be valuable to prevent health ailments toward improving human health and in-turn societal health and global health.

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