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Mineral Interactions with Other Nutrients

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ABSTRACT
The negative interaction of metal ions is one of the major dietary factors that cause low bioavailability of these nutrients. Interactions of nutritional significance include sodium-potassium, calcium-magnesium, manganese-iron, iron-copper, and zinc-copper. These interactions reach potential importance when the first metal of each pair listed above is in excess and the other is at the lower limit of requirement. The trace element interaction of highest practical significance in human nutrition is the negative effect of excess zinc on copper bioavailability. The nutritional importance that may be attributed to these interrelationships depends on the levels considered to be physiological for each nutrient, and on their maintenance at acceptable levels in tissues for the defense of the organism. Interaction of vitamins and minerals has been described in several metabolic situations and continues to be investigated by many authors. This interaction occurs in different ways, i.e. starting from the action of vitamins on minerals metabolism, from the action of both types of nutrients in the protection of the organism, and from the action of minerals on vitamin metabolism. The most significant example of vitamin action on mineral metabolism is the role played by vitamin D in calcium and phosphorus metabolism. The interrelationship of vitamin C and some minerals is also discussed, with emphasis on its relationship with iron.
Keywords-: *Minerals, Interrelationship, Nutritional Importance, Bioavailability*

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I. INTRODUCTION

Minerals are inorganic substances, present in all body tissues and fluids and their presence is necessary for the maintenance of certain physicochemical processes which are essential to life. Minerals are chemical constituents used by the body in many ways. Although they yield no energy, they have important roles to play in many activities in the body (**Malhotra, 1998; Eruvbetine, 2003)**. Every form of living matter requires these inorganic elements or minerals for their normal life processes (**Ozcan, 2003**).Minerals may be broadly classified as macro (major) or micro (trace) elements. The micro minerals or trace elements include at least iron, cobalt, copper, iodine, manganese, selenium, zinc and molybdenum (**Soetan *et al*., 2010**). Minerals have mutually beneficial or synergistic effects, i.e. providing more of one mineral will improve the status/metabolism of another, and other nutrients interact negatively with each other (**Lonnerdal, 2003**). Minerals are required by organisms throughout by organisms throughout life in small quantities. (UNICEF, 1998) defined minerals as nutrients that are only needed by body in minute amounts, which play leading roles in the production of enzyme, hormones and other substances, helping to regulate growth activity, development and the functioning of the immune and reproductive systems. Mineral interaction means, the impact of the nutrient on other nutrient's bioavailability. Nutrient bioavailability includes two important components, absorption and utilization. Interaction can affect all the major categories of nutrients: protein, carbohydrate, fats, vitamins and minerals. Interactions of minerals with other nutrients components of foods can alter availability. Nutrients in excessive amounts may interact with other nutrients or may even be toxic. It is reported that mercuric chloride toxicity in mammals can be overcome by co-administration of sodium selenite (**Gailer *et al*., 2000**). It has been repeatedly speculated that a deficiency in copper (Cu) or an excessive provision with dietary manganese (Mn) could play a role in spongiform encephalopathy **(Clauss *et al*., 2007**).

Mineral interactions can occur at several different levels:

In the diet – the mode of preparation of diets may be as important as diet composition in determining nutrient interactions. In the intestinal lumen- interactions at this level have received the most attention, because they determine the true availability of a nutrient for translocation through the enterocyte. In the post absorptive phase- these interactions may be in the form of physiological synergism. Conversely, negative interactions may affect circulating or storage levels of nutrients. Many factors influence mineral absorption and thus availability to the body. In general minerals are better absorbed from animal foods than from plant foods. Some minerals, particular those of a similar size and change, compete with each other absorption (**Lonnerdal, 2003**).

Interaction of calcium with other nutrients

Calcium is required for membrane permeability, involved in muscle contraction, normal transmission of nerve impulses and in neuromuscular excitability. Reduced extracellular blood calcium increases the irritability of nerve tissue, and very low levels may cause spontaneous discharges of nerve impulses leading to tetany and convulsions. Vitamin D accelerates the absorption of calcium from the gastrointestinal tract. Synergistic nutrients of Calcium are Vitamin D, Potassium, and Antagonistic nutrients are Iron, Magnesium, Manganese, phosphorus, sodium and Zinc (see the table: 1.1**).** High consumption ofpotassium reduces the urinary excretion of calcium. High intake of sodium, caffeine, or protein causes an increase in the urinary excretion of calcium. Certain types of dietary fiber like the fiber found in wheat and oat bran may interfere with calcium absorption by decreasing transit time, limiting the amount of time during digestion for calcium to be absorbed (**Malhotra, 1998; Murray *et al*., 2000**).

Interactions of Copper with other nutrients

Copper is known to react with a variety of other nutrients like iron, zinc, molybdenum, sulphur, selenium and vitamin C. Iron and zinc interfere with absorption of copper. Zinc supplements, when taken at 50 milligrams or more on a daily basis over an extended period of time can lower availability of copper. Copper is an essential micro-nutrient necessary for the hematologic and neurologic systems (**Tan *et al*., 2006**). Synergistic nutrients of Copper are Calcium, Iron, sodium, Selenium, zinc and Antagonistic nutrients are Iron, potassium and Zinc. (See the table: 1.1). It is necessary for the growth and formation of bone, formation of myelin sheaths in the nervous systems, helps in the incorporation of iron in haemoglobin, assists in the absorption of iron from the gastrointestinal tract (GIT) and in the transfer of iron from tissues to the plasma **(Malhotra, 1998; Murray *et al.*, 2000**).

Interactions of iron with other nutrients

Iron is required for making Haemoglobin (Hb) and it is a pro-oxidant which is also needed by microorganisms for proliferation (**Galan *et al.*, 2005**). Calcium phosphate decreases iron absorption. Vitamin C deficiency cause iron accumulation as hemosiderin. Vitamin A deficiency inhibits iron utilization and accelerates the development of anaemia. Since too much calcium usually means 300 milligrams or more, this iron –calcium interaction is not likely to cause practical problems in most food situations. But it might come into play if a person had high iron requirements and was drinking a full glass of cow’s milk along with an iron rich meal. Synergistic nutrients of Iron are Chromium, potassium, sodium, phosphorous and selenium. Antagonistic nutrients are calcium, manganese, zinc and phosphorous (see the table: 1.1**).** However, measurements of zinc absorption suggest that there is less interaction between iron and zinc in humans than in rats. Human subjects with an increased capacity to absorb iron do not absorb more zinc. Iron deficiency has been reported to have a role in brain development and in the pathophysiology of restless legs syndrome (**Tan *et al.*, 2006)**. Iron accumulation has been related to some neurologic disorders such as Alzheimer disease, Parkinson disease, type-1 neuro-degeneration with brain iron accumulation and other disorders (**Sadrzadeh and Saffari, 2004**). Brain is quite sensitive to dietary iron depletion and uses a host of mechanisms to regulate iron flux homostatically **(Batra and Seth, 2002**).

Interaction of Potassium with other nutrients

Potassium deficiency affects the collecting tubules of the kidney, resulting in the inability to concentrate urine, and also causes alterations of gastric secretions and intestinal motility (**Streeten and Williams, 1998**). Potassium is known to interact with almost all of the essential macronutrients, secondary nutrients, and micronutrients. Synergistic nutrients are Vitamin B6, calcium, iron, magnesium, sodium, zinc, manganese and Antagonistic nutrients are vitamin B1, B12, D, calcium, copper, and sodium **(see the table: 1.1).** Potassium uptake and utilization is closely related to the availability and uptake of other nutrients. Improved response to other nutrients and increased profitability can occur only when interactions are taken into account (**Dibb, D. W., 1998**).

Interaction of Zinc with other nutrients

Higher dietary levels of Zinc are required in the presence of phytic acid to prevent par keratosis and allow for normal growth. Favours zinc absorption by decreasing the inhibitory action of phytates. Several amino acid increase zinc absorption. Folate supplementation increase faecal zinc losses in men. Non-haem iron administration decreases inorganic zinc absorption. Studies found an inhibition of intestinal zinc absorption by dietary calcium. The most important of these nutrients are copper and calcium. Synergistic nutrients are vitamin

A, B6, D, E, Chromium, magnesium, manganese, phosphorous and Antagonistic nutrients are vitamin B1, B12, D, E, Calcium, copper, iron, and phosphorus. When few foods high in calcium are included in the diet, high levels of zinc intake usually obtained from supplements can also decreases absorption of calcium from the intestine into the body. Although zinc is associated with these potential detrimental effects on copper and calcium, it is also supportive of other nutrients (**Sidhu *et al.*, 2004).**

Interaction of Iodine with other nutrients

Iodine is a basic component of the thyroid hormones, thyroxine and mono-, di-, and tri-iodothyronine and it is stored in thyroid as thyroglobulin (Murray et al., 2000).The conversion of thyroxine (T4) to triothyronine (T3) requires the removal of an iodine molecule from T4. This reaction requires the mineral selenium. The iodine molecule that is removed gets returned to the body'' pool of iodine and can be reused to make additional thyroid hormones. If body is deficient in selenium, the conversion of T4 to T3 is slowed, and less iodine is available for the thyroid to use in making new hormones. Studies show that arsenic interferes with the uptake of iodine by the thyroid, leading to goitre. In addition, dietary deficiency of vitamin A, vitamin E, zinc and iron can exaggerate the effects of iodine deficiency (**Hurell, R.F. and Hess, S. 2003**).

Interaction of selenium with other nutrients

Selenium is indirectly responsible for keeping the body’s supplies of at least three other nutrients intact are: Vitamin C, glutathione and vitamin E. Selenium is a constituent of glutathione peroxidase (**Murray et al., 2000**). Synergistic nutrients of Selenium are calcium, iron, manganese, sodium and zinc. It is a constituent element of the entire defence system that protects the living organism from the harmful action of free radicals. Organic selenium is more thoroughly resorbed and more efficiently metabolized than its inorganic equivalent, which is poorly resorbed and acts more as a pro-oxidant provoking glutathione oxidation and oxidative damage to the DNA (**Schrauzer, 2000; Wycherly et al., 2004**).

Interaction of magnesium with other nutrients

Magnesium can compete with calcium and prevent calcium from trigger certain events, like the relay of a nerve message or the contraction of a muscle. Because of the complex relationship between calcium and magnesium, healthy diets almost always need to contain food rich in both minerals. Synergistic nutrients of Magnesium are vitamin A, C, D, K, Iron, calcium, zinc, and magnesium. Antagonistic nutrients are Vitamin B9, B12, D, Calcium, copper, iron, sodium, phosphorus, and manganese (see the table: 1.1). Magnesium also has a movement of potassium in and out of our cells. **(Lutsey *et al*.2014**) found that lower serum magnesium coupled with high serum calcium and phosphorus was a risk factor for heart failure. Mg is also an essential activator for the phosphate-transferring enzymes myokinase, diphophopyridine nucleotide kinase, and creatine kinase. It also activates pyruvic acid carboxylase, pyruvic acid oxidase, and the condensing enzyme for the reactions in the citric acid cycle. It is also a constituent of bones, teeth, enzyme cofactor, (kinases, etc) (**Murray *et al.*, 2000**).

Interaction of Chromium with other nutrient

Chromium found in nucleoproteins isolated from beef liver and also in RNA preparations **(Uppala *et al.*, 2005**). It could play a role in maintaining the configuration of the RNA molecule, because Cr has been shown to be particularly effective as a cross-linking agent for collagen (**Eastmond *et al.*, 2008**). Synergistic nutrients of Chromium are vitamin B3, B5, B6, C, Potassium, magnesium; zinc and Antagonistic nutrients are calcium, iron, and manganese, phosphorous (**see the table: 1.1).** Chromium has also been identified as the active ingredient of the glucose tolerant factor (**Brown, 2003**), a dietary factor required to maintain normal glucose tolerance in the rat. Trivalent chromium is a constituent of ‘‘glucose tolerance factor’’ (GTF), which binds to and activates/potentiates insulin action **(Murray *et al.*, 2000**). Vitamin C increases the absorption of Chromium. As a result, a diet rich in whole grains is still unlikely to increase our risk of chromium deficiency (**Sandstorm, B. 2001**).

Interaction of Sodium with other nutrients

The changes in osmotic pressure are largely dependent on sodium concentration (**Malhotra, 1998; Murray *et al.*, 2000)**. Its metabolism is regulated by aldosterone. Commonly used vegetable foodstuffs do not contain sufficient quantities of sodium to meet the animal’s dietary need. This inadequacy is compensated for by including sodium chloride, common salt, in their diet or by allowing them to consume salt ad libido. Sodium is readily absorbed as the sodium ion and circulates throughout the body. Synergistic nutrients of sodium are VitaminB6, D, calcium, copper, iron, selenium, magnesium. Antagonistic nutrients are Vitamin A, B2, B3, calcium, potassium, magnesium, and zinc (see the table: 1.1**).** Excretion occurs mainly through the kidney as sodium chloride or phosphate. There are appreciable losses in perspiration, and the quantities lost by this route vary rather markedly with the environmental humidity. Increased level of sodium in the serum is called hypernatremia and this occurs in Cushion's disease, administration of adrenocorticotropic hormone (ACTH), administration of sex hormones, diabetes insidious and after active sweating **(Malhotra, 1998**).

Interaction of Phosphorus with other nutrients

Practically, every form of energy exchange inside living cells involve the forming or breaking of high-energy bonds that link oxides of phosphorus to carbon or to carbon-nitrogen com-pounds (**Malhotra, 1998; Murray *et al.*, 2000**). Vitamin D is probably involved in the control of phosphorus absorption and serum levels are regulated by kidney reabsorption. Synergistic nutrients are Vitamin D, calcium, iron, magnesium, sodium, zinc and Antagonistic nutrients are vitamin D, calcium, copper, iron, magnesium, sodium, zinc (see the table: 1.1). Phosphorus is an essential macronutrient for plants and one of the three nutrients generally added to soils in fertilizers because of its vital role of energy transfer in living organisms and in plants. Adequate phosphorus availability stimulates early growth and hastens maturity in plants (**Sharma *et al*., 2008**).

II. Conclusion

A number of interactions between micronutrients could take place when high dose of a single nutrient is given or when the supply of an individual micronutrient is inadequate. These potential risks for interactions have to be taken into account when food fortification or supplementation programmes are initiated, especially when directed to population groups with high micronutrient requirements. The interactions between iron, zinc supplementation may affect copper dependent iron metabolism and immune functions.

Table: 1.1 Mineral Antagonist and Analogous/Agonist/Synergists-

Minerals	**Antagonist**	**Agonist/Synergist**
Calcium	**Vitamin**- A, C, B1, B3, B6, E **Minerals**- Iron, Magnesium, Zinc, Sodium	**Vitamins**: A, C, D, K **Minerals;** magnesium
Iron	**Vitamins**: E **Minerals**: Calcium, Copper, Manganese, Phosphorus, Zinc	**Vitamins;** B2, B9, B12, C **Minerals:** chromium, sodium, selenium, manganese
Zinc	**Vitamins**: B1, B12, D, E **Minerals**: Calcium, Copper, Iron, Phosphorus	**Vitamins:** A, B6, D, E **Minerals:** chromium, magnesium, manganese, phosphorous
Phosphorus	Vitamin D **Minerals:** Calcium, Copper, Iron, Magnesium, Manganese, Zinc	Vitamin D **Minerals:** calcium, iron, magnesium, sodium, Zinc
Magnesium	**Vitamins:** B9,B12, D, E **Minerals**: Calcium, Copper, Iron, Sodium, Phosphorus, Manganese	**Vitamins:** B1, B6, C, D **Minerals:** Iron, calcium, Zinc, magnesium
Sodium	**Vitamins**: A,B2,B3 **Minerals**: Calcium, Potassium, Magnesium, Zinc	**Vitamins**: B6, D **Minerals:** calcium, copper, iron, selenium, magnesium.
Chromium	**Minerals:** Calcium, Iron, Manganese, Phosphorous	**Vitamins**: B3, B5, B6, C **Minerals**: potassium, magnesium, zinc
Selenium	**Vitamins**: A, B2	**Vitamins**: B3, C, E **Minerals:** calcium, iron, manganese, selenium, potassium
Potassium	**Vitamins:** B1, B12, D **Minerals:** Calcium, Copper, Sodium	**Vitamins:** B6. **Minerals:** calcium, iron, magnesium, sodium, zinc, manganese
Copper	**Vitamins**: A, B3, B5,B6, C **Minerals:** Iron, potassium, zinc	**Vitamins:** B2, B6, B9 **Minerals:** calcium, Iron, Sodium, Selenium, zinc

Source: *Return2Health limited* (2015).

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