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Zinc: Importance of Zinc in Human Nutrition and Health in Plant Based Diet

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ABSTRACT

Zinc is an essential trace element and thus zinc deficiency may severely affect human health. Since plant sources of zinc contain phytate and other inhibitors of zinc absorption, vegetarians and vegans may potentially be at risk of zinc deficiency. Present review has studied the evidence about zinc in relation to vegetarians, including the bioavailability of zinc from plant sources. It has also emphasized various health benefits of zinc based diets under the light of previously published literature.

Key Words : Zinc, Supplementation, Bioavailability, Vegetarians

INTRODUCTION

Zinc as an essential trace element with wide public health and clinical significance has been reviewed by FAO/WHO (2002). The wide distribution of zinc in all body tissues and fluids reflects its essential role in metabolic activity as a component of key cell enzymes. The body's total zinc content ranges from about 1.5 g in women to 2.5 g in men. Skeletal muscle accounts for approximately 60 percent of the total body content and bone mass for approximately 30 percent. Plasma zinc has a rapid turnover rate and it represents only about 0.1 percent of total body zinc content. This level appears to be under close homeostatic control. High concentrations of zinc are found in the choroid of the eye 274 µg/g and in prostatic fluids 300-500 mg/l.

Zinc is an essential component of a large number (>300) of enzymes participating in the synthesis and degradation of carbohydrates, lipids, proteins, and nucleic acids as well as in the metabolism of other micronutrients. Zinc stabilizes the molecular structure of cellular components and membranes and contributes in this way to the maintenance of cell and organ integrity. Furthermore, zinc has an essential role in polynucleotide transcription and thus in the process of genetic expression. Its involvement in such fundamental activities probably accounts for the essentiality of zinc for all life forms. Zinc plays a central role in the immune system, affecting a number of aspects of cellular and humoral immunity (Meika and Samir, 2017).

The ubiquitous nature of zinc highlights its importance in human health and contributes to the recognition of zinc deficiency as a global public health concern (Wuehler *et al.*, 2005). Human zinc deficiency was first discovered in the Middle East in young men consuming predominantly plant-based diets that were high in wheat and low in animal protein (Prasad *et al*., 1961, 1963). Populations in low- and middle-income countries (LMIC) who follow predominantly plant-based diets continue to be at risk of diet-induced overt zinc deficiency, which is characterized by severe growth retardation, delayed sexual and bone maturation, impaired immunity, and diarrhea (Samman, 2012). In high-income countries (HIC), severe zinc deficiency is rare; however, based on population estimates of zinc intake, zinc deficiency in a less obvious form is believed to be highly prevalent (Wuehler *et al.*, 2005).

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The scientific literature suggests that in HIC vegetarians is one of the populations that are most at risk of subclinical zinc deficiency. Although plant based diets are reported to provide a variety of health benefits, zinc is less bioavailable when obtained from plant-derived compared with animal food sources (Craig and Mangels, 2009).

Bioavailability of zinc–inhibitors and enhancers:

The main inhibitor of dietary zinc absorption is phytic acid found in legumes, unrefined cereals, seeds and nuts. Phytate forms an insoluble complex by chelating with zinc, inhibiting absorption.The molar ratio of phytate to zinc in the diet has been used to predict zinc bioavailability, and ratios greater than 15 have been associated with suboptimal zinc status (Adam *et al.*, 2002). The inhibitory effect can be overcome by food processing techniques that use enzymes or thermal processing to hydro-lyse phytic acid. Wheat grain contains the enzyme phytase that breaks down phytate during yeast fermentation, and the heat during baking destroys over 50% of the phytate in yeast-leavened whole meal breads or sourdough breads.10 Soaking and sprouting beans, grains and seeds also reduces phytate (Samman, 2007). Modern processing methods such as leavening and fermentation often achieve a molar ratio of phytate to zinc of below 12, so bioavailability is less of an issue. Zinc absorption from some legume-based diets (eg, white beans and lupin protein) is comparable with animal-protein-based diets despite higher phytate content in the legumes. Due to modern processing methods and the wide variety of plantderived foods rich in zinc, zinc deficiency is less likely to be a problem in Western vegetarian diets compared with plant-based diets in developing countries (Hunt *et al.,* 2008).

Taking iron supplements may also inhibit zinc absorption, although the presence of iron in a meal that also contains zinc does not reduce zinc absorption. In the past, calcium and dietary fibre were also thought to inhibit zinc absorption; however, several studies have shown no significant differences in zinc absorption when calcium was added to infant cow's milk formula compared with the regular level of calcium. Similarly, although foods high in phytic acid also contain high amounts of dietary fibre, fibre itself does not interfere with zinc absorption (Chiplonkar and Agte, 2006).

Some studies have shown that the total amount of zinc in a meal may have a greater effect on zinc absorption than the presence of phytate. For example, in a comparison of white and wholemeal bread, the much higher zinc content of wholemeal bread resulted in more zinc being absorbed overall, even though bioavailability was half that of the white bread (Mangels *et al.*, 2011).

Sulphur-containing amino acids (cysteine and methionine, found in a range of seeds, nuts, grains and vegetables) and hydroxy acids (citric acid found in citrus fruits, lactic acid in sour milk, malic acid in apples, tartaric acid in grapes) bind to zinc and enhance its absorption. Organic acids that are present in foods or produced during fermentation can also enhance zinc absorption but probably do so to a lesser extent than for iron absorption. Higher levels of dietary protein enhance zinc absorption, as zinc binds to proteins. Different types of protein influence zinc absorption in different ways. Casein in milk has an inhibitory effect on zinc absorption, whereas soy protein does not. The greater availability of zinc from human milk compared with cow's milk, which has much higher casein content than human milk, is an example of how protein digestibility influences zinc absorption (FNB and IM, 2001).

Zinc regulation, absorption and adaptation:

The body has homeostatic mechanisms that tightly regulate plasma zinc concentration in spite of diverse dietary zinc intakes and differences in bioavailability. These mechanisms maintain zinc sufficiency by reducing endogenous zinc losses and increasing the efficiency of zinc absorption. Metallothionein and zinc transporters sense zinc status and coordinate exogenous and endogenous absorption, secretion and distribution. If zinc balance is not maintained, zinc is mobilised from a small, vulnerable and rapidly exchangeable pool (NRC, 2006). Plasma zinc concentrations and zinc bound to metallothionein are part of the zinc pool. Considerable amounts of zinc come from endogenous sources such as pancreatic secretions.Gut and pancreatic metallothionein concentrations respond rapidly to changes in dietary zinc intake, helping to maintain zinc homeostasis.The efficiency of zinc absorption also increases during periods of high physiological demand (infancy, pregnancy and lactation). Plasma zinc concentrations are also influenced by infection, stress and fasting (Maret and Sandstead, 2006).

Adaptation appears to occur in vegetarians, with zinc status likely to remain stable after an initial adjustment period. Reduced plasma and urinary zinc levels have been seen in the first 3 months of changing to a vegetarian

diet, with no further reductions during 9 months of follow-up. This may be due to reduced endogenous zinc losses and increased efficiency of zinc absorption. Hence, vegetarians may have a lower zinc intake than non-vegetarians, but their zinc status appears to be protected after an initial adjustment period (Mangels *et al.,* 2011).

Health benefits:

- **Skin Care**: Studies have shown zinc to be an effective home remedy for curing pimples or acne. It is even more powerful than placebo and consumption of antibiotic medication is still considered to be more effective.
- **Eczema:** Also called as atopic dermatitis, is an inflammatory and chronic disorder of skin. It is mainly caused by deficiency of zinc in the body. Zn plays an important role in healing chronic infection and assists the body in restoring its ability to heal properly.
- **Acne:** This mineral is important for erasing acne from skin. It regulates in controlling the amount of testosterone in the body which plays a dominant role in causing acne. In addition to it, zinc is also concerned with collagen synthesis. This further aids in normalizing the amount of skin oils and maintenance of a healthy skin.
- **Wound healing:** Deficiency in zinc causes delayed healing of wounds. Human body has several Zn dependent enzymes, which promote the synthesis of collagen that there by aids in wound healing.
- **Prostate disorder:** Zn is very important in dealing with prostate disorders. Zn deficiency causes enlargement of the prostate gland and makes it vulnerable to cancer. It is advisable to take 15mg of zinc every day, under close medical observation, when suffering from prostate disorder.
- **Cold**: Zn supplements help in decreasing the severity and duration of cold illness. It reduces the amount of proinflammatory cytokinesis, which is aggravated during the cold infections.
- **Weight loss:** Zn plays a leading role in weight loss and in controlling the Appetite of the person.
- **Pregnancy:** It is essential for the repair and functioning of DNA. It is hence, necessary for quick growth of cells and building of major constituents of the cell during the course of pregnancy.
- **Reproduction:** In males, Zn assists in spermatogenesis and development of the sex organs. While in females, it aids in all the reproductive phases, including parturition and lactation stages.
- **Biological Functions:** Zn plays a vital role in many biological functions such as reproduction, diabetes control, stress level, immune resistance, smell and taste, physical growth, appetite and digestion.
- **Infection:** Zn helps a person to sense the taste and smell, provides an aid to wound healing, boosts immunity and helps in promoting the fetus growth. It helps in protecting against the infectious disorders and fungal infections, which includes pneumonia and conjunctivitis.
- **Antioxidant:** Zn acts as an antioxidant and is basically involved in some of the biochemical decisive reactions, which includes protein synthesis, enzymatic function and carbohydrate metabolism.
- **Enzymes regulation:** Zn is a component of a number of enzymes, which help in regulation of cell growth, protein synthesis, hormonal level, DNA, regulating the gene transcription, energy metabolism and other related health benefits of zinc.
- **Cancer:** In males, Zn plays a vital role in the prostate gland and prevents the early damage, which can lead to problems like cancer.
- **Chronic Fatigue:** People suffering from chronic fatigue are suggested to consume fish, as it is rich in zinc. The doctors suggest no other medications are required for curing chronic fatigue except the intake of fish oil rich in zinc content.
- **Alopecia:** Alopecia causes loss of hair in both children and adults. Remedies suggested by the doctors to the people suffering from it, should intake a diet rich in zinc (Debjit *et al.,* 2010).

Conclusion:

To determine the prevalence of zinc deficiency across the life cycle in populations consuming plant-based diets, a more complete understanding is required of the relationships among zinc nutriture, physiological adaptations in zinc metabolism during periods of increased

requirement, and health outcomes. Important sources of zinc for vegetarians include whole grains, legumes and soy products, nuts, seeds, as well as fortified cereals and dairy. Vegetarians in Western societies have access to a wide variety of zinc rich plant derived foods, and methods of food preparation can aid zinc absorption. Concerns regarding the inhibitory effects of phytate on zinc absorption are minimised by modern food processing and cooking methods. Ensuring adequate levels of zinc intake should be a key component in efforts to reduce illness. It is essential to educate, inform and motivate communities to modify the diet to include animal products and cereals like maize and wheat products alongside vegetables to enhance zinc absorption which are rich in zinc. Further research is needed to better understand zinc metabolism and requirements in vegetarians.

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