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Plants Use in Human Zinc Deficiency: A Review

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Abstract: Zinc is vital for human health, playing key roles in essential physiological processes like DNA synthesis, immune function, and cellular activity. Despite its significance, zinc deficiency is a widespread health issue impacting billions worldwide. While zinc supplementation is commonly used, incorporating plant-based foods rich in phytochemicals presents an additional strategy to combat zinc insufficiency. Phytochemicals, abundant in fruits, vegetables, and legumes, interact with zinc in intricate ways, influencing how it is absorbed and utilized by the body. However, the relationship between plant compounds and zinc absorption is complex, with some compounds facilitating absorption while others impede it. Understanding these interactions is critical for optimizing dietary approaches to prevent zinc deficiency. Dietary factors, especially in regions where cereal-based diets dominate and lack diverse plant foods rich in zinc, exacerbate the prevalence of zinc insufficiency. Zinc deficiency can go unnoticed, posing challenges for diagnosis due to its varied physiological effects. Plant-derived compounds like polyphenols, flavonoids, and saponins have emerged as potential allies in addressing zinc deficiency, yet their effects vary depending on the context. While zinc supplementation remains a common method, recent research suggests that plant-based compounds hold promise in enhancing zinc absorption. This review delves into the history of zinc research, its physiological impacts, absorption mechanisms, and therapeutic potentials. Furthermore, it explores the role of plants in human zinc therapy, offering insights into future approaches to tackling zinc deficiency through plant-based interventions. Collaborative efforts spanning various disciplines are essential to effectively address the global burden of zinc deficiency and advance public health outcomes.

Keywords: Zinc deficiency, Plants, Zinc absorption, Global health, Zinc mechanism.

1. Introduction

Zinc, an essential micronutrient, plays a fundamental role in numerous physiological processes crucial for human health. Despite its importance, zinc deficiency remains a significant global health concern, affecting approximately two billion people worldwide. Zinc plays a major role in many bodily functions, including the production of DNA, maintenance of a robust immune system, and appropriate cell function [1]. Phytochemicals are naturally occurring molecules found in plants that can improve the body's absorption and utilization of zinc. We can prevent zinc insufficiency by improving our dietary practices by better understanding how these plant chemicals interact with zinc in our bodies [2]. It is common for people to take zinc supplements to make up for inadequate dietary intake, but eating a more plant-based diet may also be beneficial. Phytochemicals are naturally occurring molecules found in plants that can improve the body's absorption and utilization of zinc [3]. We can prevent zinc insufficiency by improving our dietary practices by better understanding how these plant chemicals interact with zinc in our bodies [4]. The prevalence of this deficiency stems from inadequate dietary intake, particularly in regions where diets are predominantly cereal-based and lack diversity in plant-based foods rich in zinc. The insidious nature of zinc deficiency lies in its ability to manifest silently within the body, often progressing unnoticed until severe symptoms arise [5]. As such, diagnosing zinc insufficiency presents a considerable challenge, given its diverse array of physiological effects.

From impairing immune function to compromising neurological health and DNA integrity, zinc deficiency can destroy multiple organ systems, leading to long-term health complications such as cancer, cardiovascular disease, and neurological disorders [6]. In the quest to combat zinc deficiency, understanding the intricate interplay between dietary factors and zinc absorption is paramount. While zinc supplementation has been a conventional approach to addressing deficiency, recent research has shed light on the potential of plant-based compounds to enhance zinc absorption and utilization within the body [7]. Polyphenols, flavonoids, saponins, and other bioactive compounds abundant in fruits, vegetables, and legumes have emerged as promising allies in the battle against zinc deficiency [8]. However, the story of zinc absorption is not without its complexities. Certain substances present in plant-based foods, such as tannins and phytates, may exert inhibitory effects on zinc absorption, underscoring the need for a nuanced understanding of dietary interactions [9]. Moreover, the synergistic effects of vitamins A and C, prevalent in many plant foods, further complicate the landscape of zinc metabolism, offering both challenges and opportunities in optimizing zinc intake [10].

2. History of Zinc

Although farmers have long recognized the importance of zinc, this realization came later. A Louis Pasteur student discovered in 1869 that the fungus Aspergillus niger, which can harm crops like grapes, onions, and peanuts, need zinc to thrive [11]. However, scientists did not confirm this finding until 1911. Then, in 1914, it was found that zinc was also necessary for maize cultivated in the soil to thrive effectively [12]. Ten years later, significant zinc insufficiency was discovered in developed nations, particularly in those with acrodermatitis enteropathica, an uncommon hereditary condition that impairs zinc metabolism [13]. Physicians noticed in the 1970s and later that some patients receiving all their nourishment through IV tubes were deficient in zinc because the mineral was not supplemented in their IV fluids. Most of our knowledge of zinc insufficiency comes from researching individuals who have these genetic or acquired impairments [14]. Since the early 1960s, there has been speculation as to whether deficiencies in zinc or abnormalities related to zinc in the body may be associated with a range of health concerns, such as recurrent infections or delayed wound healing following surgery [15]. There have been a few documented instances of individuals with low zinc levels who appeared to have additional health issues. Nevertheless, most of these investigations were either too small or poorly conducted to determine the precise prevalence of zinc deficiency or its relative significance in various disorders in the United States [5]. More research has been done on zinc shortage in diet, particularly in young children. Research conducted in Denver in the 1970s and 1980s revealed that a deficiency in zinc in the diet caused development issues in some otherwise healthy newborns and early children [16]. These studies were significant because they sparked more studies in the 1990s, particularly in poorer nations. In this study, participants were given zinc supplements to examine if they improved any health problems [17]. These research findings demonstrated that zinc insufficiency is a widespread issue that can lead to several illnesses and developmental problems. The history of research on zinc in nutrition and health demonstrates how crucial it is for scientists from many nations to collaborate to comprehend and solve global health issues [4].

3. Physiological Effects on Zinc Deficiency

Zinc, a vital trace element, plays vital roles in numerous physiological processes, encompassing growth, development, immune function, and cellular metabolism. Insufficient zinc levels can trigger significant physiological disruptions within the body. This delves into the ramifications of zinc deficiency across various body systems [18].

3.1 Growth and Development

Zinc stands as a cornerstone for normal growth and development, particularly during the crucial stages of infancy, childhood, and adolescence. Inadequate zinc intake can lead to growth retardation, delayed sexual maturation, and compromised bone formation. Children experiencing severe zinc deficiency may exhibit signs of stunted growth and developmental delays [19].

3.2 Immune Function

Zinc serves as a linchpin in bolstering immune function, facilitating the development and operation of immune cells like T cells, B cells, and natural killer cells. Depleted zinc levels can compromise immune responses, heightening susceptibility to infections, particularly respiratory ailments and diarrheal diseases. Additionally, impaired wound healing and prolonged convalescence from illnesses are common consequences of zinc deficiency [20].

3.3 Skin and Hair Health

Zinc plays an integral role in maintaining skin integrity and fostering wound-healing processes. Zinc deficiency often manifests as dermatitis, characterized by parched, rough, and scaly skin. Moreover, insufficient zinc levels may contribute to hair loss (alopecia) and hindered wound healing [21].

3.4 Neurological Function

Zinc is indispensable for maintaining normal neurological function, including the synthesis of neurotransmitters and neuronal signaling. Deficiencies in zinc have been correlated with cognitive impairment, memory deficits, and mood disorders such as depression and anxiety. In severe cases, zinc deficiency can provoke neurological symptoms reminiscent of conditions like Alzheimer's disease [22].

3.5 Reproductive Health

Zinc emerges as a critical player in ensuring reproductive health for both males and females. In males, inadequate zinc levels can precipitate hypogonadism, diminished sperm quality, and infertility. Similarly, females may experience disruptions in ovarian function and menstrual cycle regulation due to zinc deficiency [23].

3.6 Olfaction and Taste Sensation

Zinc contributes to the functionality of taste and olfactory receptors. A dearth of zinc can impair taste sensation (dysgeusia) and diminish olfactory perception (hyposmia or anosmia) [24].

4. Mechanism of Zinc Absorption

Zinc absorption from dietary sources is a complex process governed by specific transport mechanisms within the small intestine, particularly in the duodenum and jejunum [25]. This process is the ZIP and ZnT transporter families, which play vital roles in facilitating zinc uptake by enterocytes and its subsequent release into the bloodstream to maintain systemic zinc balance [26]. However, the efficiency of zinc absorption can be influenced by various dietary compounds commonly found in plant-based foods. Polyphenols, present abundantly in fruits, vegetables, and beverages such as tea and wine, possess properties that enable them to bind with zinc ions, forming complexes that hinder their absorption [27]. Similarly, certain flavonoids and saponins in plant foods have been observed to interfere with zinc absorption by forming complexes with zinc within the intestinal lumen [28]. Conversely, vitamins A and C are known to enhance zinc absorption. Vitamin A aids in the production of metallothionein, a protein that regulates zinc levels in enterocytes, while vitamin C enhances zinc solubility in the intestinal lumen, facilitating its uptake [29]. However, the overall impact of these dietary compounds on zinc absorption can vary depending on factors such as their concentration, availability, and interactions with other nutrients [30]. Moreover, an individual's nutritional status, gastrointestinal health, and genetic factors can further influence zinc absorption and utilization. Recognizing the intricate relationship between dietary compounds and zinc absorption mechanisms is essential for optimizing zinc intake and ensuring adequate zinc levels for overall health and well-being [31].

Table 1: Impact of Plant-Based Compound on Zinc deficiency.

Sr. No.	Plant-Based Compound	Mechanism of Action	Impact of Zinc Absorption	Reference
1.	Polyphenols	Possess metal-binding properties, allowing them to combine with zinc ions and create insoluble complexes.	Hinder zinc absorption by decreasing its accessibility for uptake in the intestinal tract.	[10]

2.	Flavonoids	Interfere with zinc absorption by bonding with zinc within the intestinal tract.	Diminish zinc availability by attaching to zinc ions and impeding their absorption into enterocytes.	[32]
3.	Saponins	Create bonds with zinc in the intestinal tract, obstructing its absorption.	Reduce zinc absorption by associating with zinc ions, thereby limiting its availability for uptake by enterocytes.	[33]
4.	Phytates	Form complexes with zinc in the gastrointestinal tract, reducing its solubility and bioavailability.	Inhibit zinc absorption by binding with zinc ions, making them less accessible for uptake.	[34]
5.	Oxalates	Combine with zinc in the intestine to form insoluble complexes, inhibiting its absorption.	Diminish zinc bioavailability by forming complexes with zinc ions, impeding their uptake into enterocytes.	[35]
6.	Tannins	Bind with zinc in the gut, forming insoluble complexes that limit its absorption.	Decrease zinc absorption by binding with zinc ions, reducing their availability for uptake in the small intestine.	[36]

5. Function of Zinc in Plant Development

For the growth of both humans and animals, zinc is crucial. It aids in feeding and participates in a variety of enzyme reactions in plants, which are like chemical processes that maintain plant health. These enzymes aid in the breakdown of carbohydrates, the synthesis of proteins, and the transmission of energy [37]. In addition, zinc is involved in the metabolism of carbohydrates, photosynthesis, and the conversion of sugars to starch. It is also necessary for the metabolism of proteins, the production of growth hormones, the production of pollen, the maintenance of healthy cell membranes, and the defense of plants against disease-causing pathogens [38]. Zinc is involved in several plant processes, including the creation of cytochromes, carbonic anhydrase, hydrogenase, and ribosomal functions [39]. It stimulates certain plant enzymes that are involved in the synthesis of proteins, the regulation of growth hormones, the integrity of cell membranes, the metabolism of carbohydrates, and the formation of pollen [40]. Certain genes in plants enable them to withstand environmental stressors, and zinc is required to sustain and control the expression of these genes [41]. Plants that are deficient in zinc exhibit outward symptoms such as reduced leaf size, yellowing leaves, stunted development, and sterility in the reproductive organs. Lack of zinc makes crops more susceptible to illnesses and damage from extreme heat and light [42]. Zinc is essential for plant development, but it also supports healthy immunological function. It is required to produce several hormones that support the development and healthy operation of our immune cells [43]. Our immune system cannot fight off infections as well without adequate zinc, and it may even raise our chance of developing cancer. The defense systems in our bodies function less effectively when there is insufficient zinc [44]. This contains vital cells that fight against infections, such as natural killer cells and macrophages. By increasing both our innate and adaptive immunity, taking zinc supplements can help our bodies fight off diseases like E. coli [45]. Our immune system may malfunction if we do not get enough zinc, which can cause problems including thymus gland shrinkage, heightened inflammation, and compromised immunological responses [46].

Table 2: List of some plants used to combat zinc deficiency.

Sr. No.	Plant	Mechanism of action	Family	Source	Uses in Zinc Deficiency	Reference
1.	Spinach	Contains oxalates, which may	Amaranthaceae	Leafy green vegetable	Spinach is rich in zinc and can be consumed to supplement dietary	[47]

		prevent the absorption of zinc			zinc intake in cases of deficiency.	
2.	Pea	Nitrogen Fixation and Photosynthesis	Fabaceae	Legume	Peas are a good source of zinc and can be incorporated into the diet to help address zinc deficiency.	[48]
3.	Broccoli	Contains phytates, which can inhibit zinc absorption.	Brassicaceae	Leafy green vegetable	Broccoli and Brussels sprouts, belonging to the Brassica family, contain zinc and can be beneficial in combating zinc deficiency.	[49]
4.	Onion	Contains phytates, which can inhibit zinc absorption.	Amaryllidaceae	vegetable	Onions, belonging to the Allium family, contain zinc and can be included in the diet to boost zinc levels.	[50]
5.	Beetroot	Contains phytates, which can inhibit zinc absorption.	Amaranthaceae	Root vegetable	Beetroots, rich in various nutrients including zinc, can be consumed to mitigate zinc deficiency.	[51]
6.	Legumes	Contains phytates, which can inhibit zinc absorption.	Fabaceae	Vegetable	Legumes such as lentils, chickpeas, and beans are rich sources of zinc, making them valuable in addressing zinc deficiency.	[52]
7.	Pumpkin seeds	Contains phytates but also provides nutrients like vitamin E and healthy fats that can support zinc absorption.	Cucurbitaceae	Seeds	Pumpkin seeds are high in zinc content and can be consumed as a snack or added to meals to increase zinc intake.	[53]
8.	Sunflower seeds	Contains phytates but also provides nutrients like vitamin E and healthy fats that can support zinc absorption.	Asteraceae	Seeds	Sunflower seeds are another excellent source of zinc and can be included in the diet to help combat zinc deficiency.	[54]

9.	Almonds	Facilitate zinc absorption through their high content of vitamin E and healthy fats	Rosaceae	Nuts	Almonds contain zinc and can be eaten as a nutrient-dense snack to supplement zinc levels in the body.	[55]
10.	Sesame seeds	Contains phytates but also provides nutrients like vitamin E and healthy fats that can support zinc absorption.	Pedaliaceae	Seeds	Sesame seeds are rich in zinc and can be incorporated into various dishes or used as a topping to enhance zinc intake.	[56]
11.	Cashews	Contains phytates but also provides nutrients like vitamin E and healthy fats that can support zinc absorption.	Anacardiaceae	Nuts	Cashews are a good source of zinc and can be included in the diet to help meet zinc requirements.	[57]
12.	Quinoa	Contain phytates, they are also rich in protein, which can facilitate zinc absorption	Amaranthaceae	Grain	Quinoa is a pseudo-cereal with significant zinc content, making it a valuable addition to the diet for individuals with zinc deficiency.	[58]
13.	Chia seeds	Contain phytates, they are also rich in protein, which can facilitate zinc absorption	Lamiaceae	Seeds	Chia seeds are rich in nutrients, including zinc, and can be added to smoothies, yoghurt, or oatmeal to boost zinc intake.	[59]
14.	Walnuts	Contains phytates but also provides nutrients like vitamin E	Juglandaceae	Nuts	Walnuts contain zinc and can be consumed as a healthy snack to increase zinc levels in the body.	[60]

		and healthy fats that can support zinc absorption.				
15.	Brazil nuts	Contains phytates but also provides nutrients like vitamin E and healthy fats that can support zinc absorption.	Lecythidaceae	Nuts	Brazil nuts are a good source of zinc and can be eaten as a snack or added to various recipes to enhance zinc intake.	[61]
16.	Lentils	Contains phytates, which may prevent the absorption of zinc.	Fabaceae	Legume	Supplies zinc for diet; nevertheless, because of its phytates concentration, it should be used with caution.	[62]
17.	Avocado	Includes monounsatu rated fats, which facilitate the absorption of zinc.	Lauraceae	Fruit	Supplies zinc through food; also includes additional elements that are good for general health.	[63]

6. Deficiency of Zinc

6.1 Zinc Nutritional Deficiency

The first documented incidence of zinc deficiency in the United States occurred in 1969 and included a Puerto Rican individual with many medical conditions, including intestinal infections, low sex hormone levels, poor immune system, and dwarfism. This person's growth and development were improved by taking zinc supplements [64]. Another research conducted in 1972 discovered that Mexican-American children in Denver likewise had low zinc levels, but that the children's condition improved upon taking zinc supplements. In a 1972 research, Halsted and associates examined fifteen individuals who had been turned away from the Iranian Army Induction Centre because they were undernourished. Two more ladies, ages 19 and 20, were also there. Every subject was around the same age. They spent six to twelve months under study. Three groups were given different treatments: a placebo, a balanced diet including animal protein, and zinc supplements. The third group just got the diet without any supplements for a period of six months. Compared to the group that merely got a balanced diet, the zinc supplement-eating group had a considerable increase in height as well as early signals of sexual maturity [65].

6.2 Severe Zinc Deficit

A 2-year-old child with severe acrodermatitis enteropathica—an uncommon illness in which the body is unable to absorb enough zinc—was described by Barnes and Moynahan in 1973. She was on a lactose-free diet and a specialized prescription for her condition, but she was not improving. According to tests, her blood zinc levels were low. So, to correct the shortage, doctors gave her zinc tablets orally. Interestingly, after she started taking the zinc tablets, her gastrointestinal issues and skin rashes disappeared. The child's symptoms returned after she stopped taking zinc, but they disappeared once again when she began taking supplements containing zinc. At first, the physicians assumed that her unique diet was the reason for her low zinc levels. However, they quickly discovered that zinc was essential for treating her uncommon acrodermatitis enteropathica. When using zinc pills, other people with the same illness also saw improvements. Because of an issue with a particular protein that aids in the transportation of zinc through the intestines, the body is unable to absorb enough zinc to create this illness [66].

6.3 Moderate Zinc Insufficiency

Lack of zinc can lead to a variety of problems, including impaired immune function, delayed wound healing, rough skin, insufficient appetite difficulties with adolescent male reproductive organs, slower development, and alterations in sensory perception. These issues have been observed in individuals with low zinc levels, particularly in Iran and Egypt, as well as in those who consume adequate zinc but still don't absorb enough of it. It is now well established that a large number of people worldwide, particularly in regions where the predominant food is grains, do not get enough zinc in their diets. Many Turkish teens who grow up in rural regions consume dirt (geophagia), and the majority of them have low blood iron and zinc levels. Because they mostly consumed grains, over 30% of pregnant Turkish women from low-income families had low zinc levels. Pregnant women who were zinc deficient had serious birth abnormalities in their unborn children, as well as more health issues for themselves [67].

6.4 Mild Zinc Deficiency

We designed an experiment to investigate mild zinc insufficiency in humans. For the study, we requested adult men to remain at the University of Michigan Medical School hospital. For four weeks, they followed a diet that provided them with the required quantity of zinc. After that, they changed to a 28-week diet that included just 3.0-5.0 mg of zinc daily. They then consumed cookies for 12 weeks that included zinc supplements. Except for zinc, we ensured that all the minerals in the meals of the participants were at the recommended levels throughout the trial. We were able to induce a minor zinc shortage in the volunteers by doing this. The slight zinc shortage that the volunteers experienced caused several physical alterations in them. These included decreased sperm counts, decreased testosterone levels, decreased immune system activity, decreased levels of specific immune-supporting proteins, elevated blood ammonia, impaired taste perception, blurred eyesight in low light, and decreased muscular mass. This study demonstrated how the body's processes may be impacted in several ways by even a slight zinc deficiency [68].

7. Therapeutic Impact of Zinc

Children under five who take zinc supplements can avoid and treat diarrhoea, which will lessen the frequency and severity of their illnesses. A zinc shortage has also been associated with an increased risk of respiratory infections; however, zinc supplements appear to be most effective in severe instances and in areas where zinc deficiency is widespread. Children who suffer from diarrheal illness have worse vitamin absorption, particularly with zinc. Their bodies thus have less zinc. According to studies, children who have low zinc levels are more likely to get diarrhea, which can start a vicious cycle whereby a lack of zinc makes a kid more vulnerable to illnesses. Numerous studies indicate that supplementing youngsters with zinc can help reduce diarrhea. When a kid has diarrhea, the World Health Organization (WHO) in 2004 advised giving them 20 mg of zinc per day for 10–14 days. This recommendation applies to children older than 6 months. It was proposed that infants under 6 months old receive 10 milligrams of zinc every day. In comparison to children who did not get zinc supplements, studies have shown that providing zinc supplements to children for up to three months can reduce the frequency of diarrhea by 18%, the total number of instances of diarrhea by 25% and the number of bouts of prolonged diarrhea by 33% [69].

8. Global Prevalence and Significance of Zinc Deficiency in Human

Zinc deficiency affects approximately 2 billion individuals, particularly in impoverished nations where diets are predominantly rich in grain proteins containing phytates, a compound that hinders zinc absorption. This deficiency can also result from various medical conditions such as liver disease and malabsorption syndrome [70]. Low zinc levels pose significant health risks, including weakened immune function, stunted growth, and cognitive impairments. In the 1960s, initially focused on its role in animal growth across species. The first documented case of zinc deficiency occurred in 1961 among the Iranian population, associated with dwarfism and delayed sexual development [71]. While initially only a few zinc-dependent enzymes were known, today, we recognize its necessity for approximately 300 enzymes and 1000 transcription factors. Over the past decades, research has increasingly explored the use of zinc supplements to address associated health issues in humans. Zinc deficiency poses a significant risk of developing various diseases, particularly in the elderly due to lower zinc intake, lifestyle changes, and global food insecurity affecting 65% of the population(10). Globally, an estimated two billion individuals are at risk of clinical illness due to zinc deficiency, with about 17.3% of the world's population consuming zinc-deficient food items. Adults are particularly susceptible to life-threatening conditions like cancer, diabetes, and chronic stress as a result of zinc deficiency. Additionally, insufficient zinc intake in adults can lead to short-term memory loss, brain structural abnormalities, reduced cognitive function, and behavioral issues. Severe zinc deficiency manifests as hyperzincuria, increased hemolysis, impaired growth, weakened immune system, infertility, hyperammonemia, hypogonadism in men, and thymic atrophy [72].

9. Currently Available Treatment of Zinc Deficiency

Zinc is more important for general health than other micronutrients and is involved in many vital body processes. Zinc is widely recognized for its role in the immune response and growth of children, but it also helps control glucose metabolism. New research has connected zinc deficiency to increased risks of diabetes and other cardiometabolic illnesses. For this reason, maintaining optimal health throughout life requires ensuring enough zinc levels [73]. Still, zinc insufficiency is a major problem that affects the entire world. Understanding the complete impact of zinc deficiency on health inequalities, especially in later life and adulthood, necessitates taking into account the role zinc plays in disorders like high blood sugar and non-communicable diseases. Unfortunately, a lack of reliable techniques for determining zinc status has hindered efforts to reduce zinc deficiency. This narrative review aims to explore recent advancements in understanding zinc's role in health, considering factors such as climate change and the global context affecting zinc intake [74]. It also discusses promising biomarkers for monitoring zinc levels in populations and proposes solutions to improve zinc intake worldwide. Implementing evidence-based interventions to prevent and control zinc deficiency across all life stages is crucial. This requires tailored strategies combining supplementation, food fortification, and agricultural approaches like biofortification. Enhancing dietary zinc content and bioavailability through biofortification presents a particularly inclusive solution, benefiting vulnerable individuals and populations with inadequate diets to the greatest extent [5].

10. The Role of Plants in Human Zinc Therapy

Plant-based diets are the major source of zinc that helps us stay healthy. They guarantee that our bodies can absorb zinc more efficiently and supply us with other healthy elements like vitamins and special plant chemicals that aid in the metabolism of zinc. Therefore, eating a lot of plants benefits us in more ways than just providing zinc; it also promotes effective zinc utilization and general health [70, 75-76].

10.1 Improved Zinc Absorption

Polyphenols and flavonoids, two naturally occurring chemicals found in plant foods, aid in the body's more effective absorption of zinc. This implies that you may maximize the amount of zinc you eat by include foods like fruits, vegetables, and legumes in your diet.

10.2 Maintaining Zinc Levels

Phytates, among other compounds found in plants, have the potential to impede the body's absorption of zinc. However, these compounds can be beneficial if you don't consume too much of them, as long as you still receive enough zinc.

10.3 Adding Extra Nutrients

Plant-based diets are an excellent source of vitamins and minerals that promote general health in addition to zinc. For example, vitamin C from fruits and vegetables enhances your body's absorption of zinc, while vitamin A preserves zinc's activity in your body.

10.4 Improving Overall Health

Eating a lot of plant-based foods gives you the essential zinc and helps avoid illnesses including diabetes, cancer, and heart disease. So, eating a lot of veggies is good for your body, not only for your zinc levels. Consuming a wide variety of plant-based meals is essential for maintaining optimal zinc levels and supporting the efficacy of zinc treatment. However, each person's diet and health are unique, so it's critical to consider our dietary preferences, our bodies' needs, and any drugs or medical conditions we may be dealing with. The ideal strategy to increase the amount of plant foods in our diets to improve the effectiveness of zinc treatment can be determined by speaking with a physician or nutritionist [77-78].

11. Conclusion

Plant-based remedies for zinc insufficiency appear to have promise for the future. Researchers are looking at novel plant chemicals that may improve the body's absorption and utilisation of zinc. Better methods for processing food to retain more zinc and beneficial plant components are also being discovered. Enriching diets with more zinc and plant-based additives may facilitate the correction of deficiencies, particularly in those who are most in need of them. Furthermore, through genome analysis, it may be possible to precisely identify the dietary categories that are most beneficial to everyone. However, further research is necessary to confirm that these plant-based remedies are secure and truly beneficial for all individuals.

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