Review

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Review

Implications of dietary antinutrient intake on selected micronutrients in humans and relations: a review

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ABSTRACT

The objective of this paper is to identify the implications of the consumption of dietary antinutrients on selected micronutrients in humans or relations. Humans and animals depend on dietary sources of nutrients for proper functioning and living. Therewith, they consume plant-based materials that contain some special metabolites popularly known as antinutrients. Antinutrients interfere with how the human body utilizes nutrients such as Fe, Zn, I, and relations; and in turn could facilitate malnutrition or deficiencies, affect learning or brain functioning, as well as development of consumers such as young ones, pregnant women, girls. It is therefore important to make a conceptual or reviewed foundation to aid policymakers and the public in taking the right steps to control antinutrients effects on nutritional health. This work reviewed the following and related themes: micronutrient deficiencies involving Fe, I, selected antinutrients affecting selected micronutrients, methods for controlling antinutrients, chemistry of interactions of antinutrients and elemental micronutrients, and approaches for tackling the problems. There is a need for nutritional awareness on how to properly deal with food nowadays.

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1. Introduction

Certainly, most of the world's deficiencies, let alone in the case of micronutrients, are dietary-based (1).

Nearly every process in the human body needs one micronutrient or the other.

Micronutrients comprise minerals and vitamins the human body needs in minute amounts to essentially grow, develop, and live healthily.

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The role of micronutrients in metabolic and anatomical functions cannot be overstated (2). Basically, micronutrients are actors in the biological system in significant ways as Cofactors of metabolic enzymes to modulate enzyme structures and activities, genetic control factors, as in the case of zinc, and act as antioxidants shielding the body from reactive oxygen species effects (2).

However, deficiencies are of many kinds. Globally, more than 2 billion people are at the risk of developing iodine deficiency with consequences of goiter, hypothyroidism, disorders, stillbirth, birth defects, cognitive problems, infant mortality, and low birth weight (3). Zinc deficiency is elevated in developing states with disorders such as low disease resistance, genetic aberrations, poor growth, increased deaths among children and mothers. Commonly, Selenium deficiency manifests as poor reproduction, poor immunity, deaths, hepatic necrosis, colon edema, etc. (4).

Nevertheless, the period of rapid growth or changes in the body requires an adequate supply of micronutrients, most, unless detriments (such as diseases, disorders, and mental derangements) are to occur. Likewise, people who experience rapid changes and consequently need more and uninterrupted supply of micronutrients are the prospective mothers, mothers (pregnant or lactating), children, and adolescents. Failure to have micronutrients at these critical life stages causes physical, as well as mental, derangement (3). The objective of this paper is to identify the implications of the consumption of dietary ant nutrients on selected micronutrients in humans or relations. Table 1-4 and Fig. 1-5 present various data.

Table 1. Some antinutrients and respective micronutrients.

Elemental micronutrient affected	Perceived mechanism	Example of a dietary source	Antinutrients
Iodine	Slow down the activity of thyroid peroxidase activity	Millet, cabbage	Flavonoids
Iodine	Compete with iodide and prevent its uptake	Cassava, Lima beans, Linseed, sweet potato	Thiocyanate
Iron	Coordination compounds	Legumes, sweet potato	Oxalate
Zinc, iron	Coordination compounds	Legumes, cereals	Phytate

Source: (4,5)

Table 2. Amounts of some Micronutrients in Earth's crust

N	Element	amount (ppm)
1	Iron	39, 200
2	Selenium	0.09
3	Zinc	67
4	Nickel	47
5	Copper	28

Source: (4,5)

2. Micronutrient deficiencies

A micronutrient deficiency is a problem due to a deficiency of a given nutrient that is essentially utilized by the biological system for vital functions such as growth, fertility, life processes, and development. When there is one or more deficiency, the condition is

dubbed as micronutrient deficiencies, for example, a combination of iron deficiency, iodine deficiency, and zinc deficiency treated together (5).

2.1. Iodine deficiency

More than 200 million people around the globe are affected by iodine disorders, with about 150 million individuals affected in Africa (6,7).

2.1.1 Metabolic needs of iodine

Presently, the role of iodine in humans is the physiologic participation in making thyroid hormones in the thyroid gland. It is therefore important to make normal thyroxine, and iodine is obtained through diet or water. The role of iodine is traced in the thyroid hormones, T4 (tetra-iodo-thyronine), released by the thyroid gland is handled by cells and converted to T3 (tri-iodo-thyronine), the active form that binds to receptors in the nucleus. Thyroid hormones are physiologically required for controlling metabolic processes, growth, and development (of the brain, and the nervous system) during the 15th week of gestation up to the period of 3 years at least; a deficiency at this point triggers an irreversible derangement in the brain, as well nervous system. On the other hand, thyroid hormone controls body processes that are diverse, such as energy production, lipolysis, regulation of neoglucogenesis, as well as control of glycolysis (8-13).

2.1.2. People at risk

People at all life phases could be affected, but people in the critical circles of lactating women, pregnant women, reproductive age women, and smaller children (2 years or less) are more affected (14,15).

2.1.3. Diets providing iodine

Seaweed, water, coral reef, meat, milk, eggs, iodized salt, grains, fruits, vegetables, legumes, fish, iodized sugar (7,16).

2.1.4. Reasons (factors) for deficiency

Environmental deficiency, environmental problems such as flooding, deforestation, goitrogens consumption, antinutritional factors intake (6,17).

2.1.5. Recommendations

Fortification through addition of iodine in foods such as adding potassium iodide to salt, use of iodine prophylaxis (such as iodized diary, iodized water, iodized poultry), etc (18).

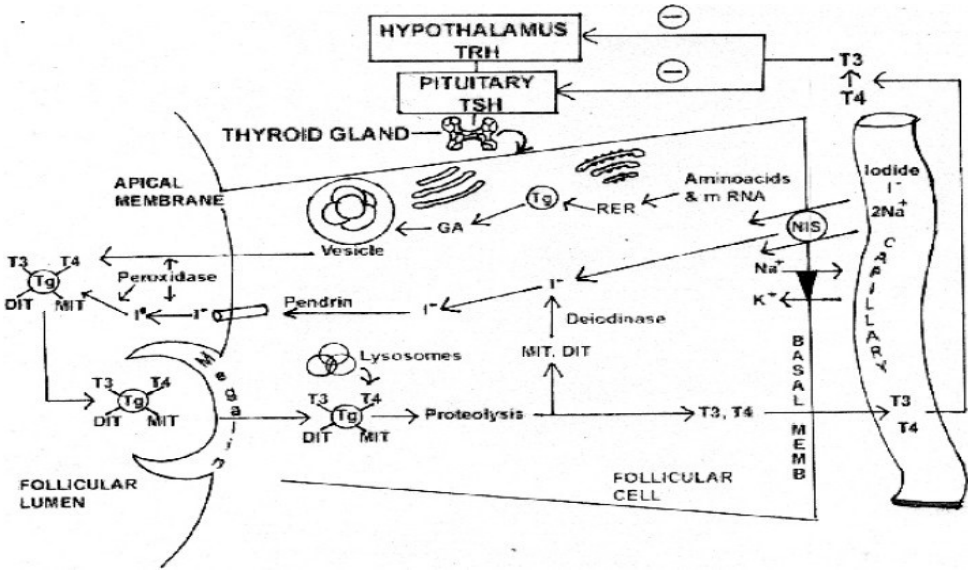

Figure 1. Illustration of iodine metabolism. Source: (13)

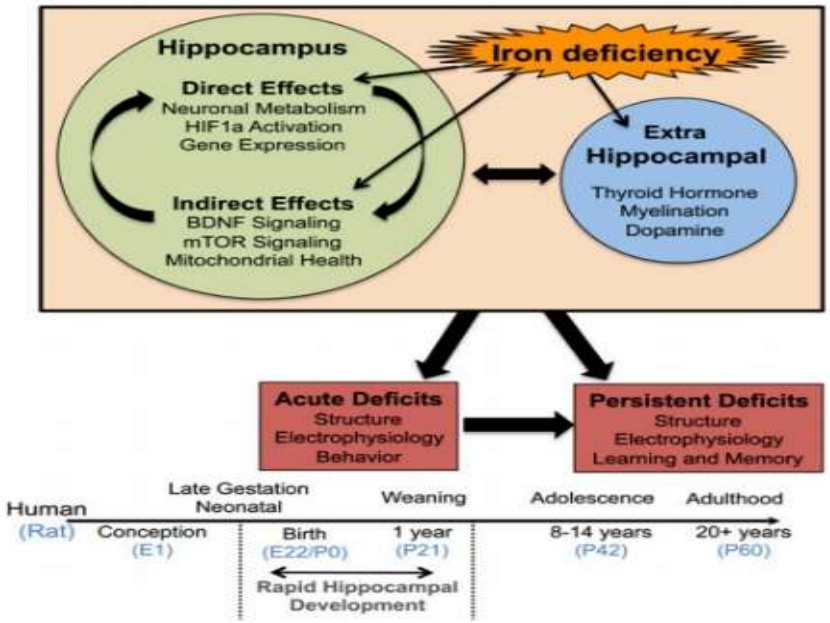

Figure 2. Overview of role of iron in brain. Source: (20)

2.2. Iron deficiency

2.2.1. Role of iron in metabolism

Iron plays several roles in the body. Parable, it participates in transport of oxygen to tissues, plays parts of many enzymes, present in myoglobin of muscle, serve in cytochromes (used for detoxification of xenobiotics, synthesis of bile, synthesis of steroid hormones), iron serve in ferritin, and hemosiderin, as well as transferrin among other services (3,19). Iron is mostly obtained from diet, albeit, the two major iron forms are heme, and non-heme, the heme iron is more absorbed. Absorption occurs depending on the availability of enhancing or inhibitory factors. Enhancement occurs due to factors such as ascorbic acid (from fruits, vegetables), meat, fish, chicken, etc; and inhibition occurs due to factors such as phytates inositol phosphates (eg. high extraction flour, oats, bread, pasta products, cocoa), phenolic groups (eg cocoa, some spices, tea, red wines, alcohols), and calcium (eg from milk, cheese, etc). Certainly, for iron to be absorbed it has to be reduced to ferrous entity. Normally, the body uses dietary iron, catabolized red cell iron, iron store when need arises, and the body losses iron through urine, skin, and relations. Therefore, an imbalance elicits deficiency (20,21).

2.2.2. People at risk

People at risk of iron deficiency include, adolescents, infants, children, childbearing women, as well as pregnant women, people taking poor iron diet, people consuming excess iron inhibitors (5,22).

2.2.3. Effects or consequences

Reduced physical ability, linked to poor brain functioning, poor immunity, poor attention, poor memory, poor learning (23).

2.2.4. Suggestions

- Iron supplementation involves giving iron tablets to specific groups such as children, pregnant women
- Iron fortification involves adding iron to foodstuffs such as flour
- Education involves making people aware about better sources of iron (24,25).

2.3. Zinc deficiency

2.3.1. Roles of zinc to the human biological system

Zinc dwell in fluids of the body, as well as tissues. More than 300 enzymes dealing with metabolism of proteins, carbohydrates, nucleic acids, lipids, micronutrients, need zinc for their specific activities. Zinc stabilizes membranes, cellular components for cell integrity; that is why, zinc deficiency is manifesting in form of diarrhea, skin lesions, alopecia, poor appetite, delayed bone maturation, delayed sexual maturation, and immune system problem (26).

2.3.2. Dietary foods providing zinc

Some of the foods that are good source of zinc are: legumes, cereals, red meat, roots, fish, tubers, fruits, green leafy vegetables. However, phytates have strong for divalent cations such as zinc; therefore, it affects availability and dietary utilization of zinc (27).

2.3.3. People at risk

Children, infants, pregnant women, adolescents.

2.4. Copper

Copper is a micronutrient essentially needed by the body for enzymes and metabolic activities. On many occasions copper deficiency is related to dietary copper malnutrition. Clinically, the deficiency manifest as osteoporosis, other bony changes, etc. Effects of copper malnutrition could be premature birth, low birth weight etc (27,28).

2.5. Selenium deficiency

Studies express the role of selenium in modulation of development and growth, defense against infection, defense against oxidative stress. Some roles of selenium could be express in the selenium proteins such as sperm capsule selenoproten, selenoprotein P, selenoprotein W, extracellular GSHPx, thioredoxin reductase, gastrointestinal hydroperoxidr GSHPx etc that help in controlling oxidative stress, and immunity. Similarly, selenium proteins essentially ensure the making of active thyroid hormone (T3) (29-31).

2.5.1. Sources in foods

Sources of selenium in diet depend on the selenium content of the environment; some of the dietary sources include cereals, fruits, fish, vegetables, meat, eggs, wheat (27,32).

3. Antinutrients affecting dietary micronutrients intake in humans or animals

Albeit, phytochemicals or antinutrients are beneficial to the plants making them, as well as functional to the humans or animals in a number of ways, some of their actions are considered negative to the nutritional health of many consumers. Some of the antinutrients affecting the specific micronutrients treated in this work are as follows;

3.1. Flavonoids

Flavonoids exert numerous antimicrobial functions, but are also reported for their ability to interfere with iron, and zinc metals intake (33). Flavonoids are widely made by plants such as berries, tangerines, oranges; therefore, many of them are consumed advertently or inadvertently. However, an elevated concentration of flavonoids been consumed could chelate iron, and zinc and on the other hand impeding their absorption by human body (34,35). One of the important notes regarding flavonoids is, their ability elicits goitre by affecting how thyroid works (36, 37).

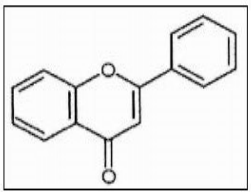

Figure 3. Flavone main backbone. Source: (36)

3.2. Phytates

Phytate or phytic acid is a major phosphate reserve in numerous plant parts such as seeds, tissues, bran, etc (38). Phytates cannot be easily metabolized by humans because phytase is in absentia, but the compound converts zinc and iron metals into forms that are unavailable to the human body (39,40).

3.3. Saponins

Saponins are soap-like metabolites present in many plant species around the world. They obtained their name due to their amphipathic nature that confer them the ability to turn soapy in water medium. In connection with iron deficiency, saponins have the ability to crumble red cells (41-43).

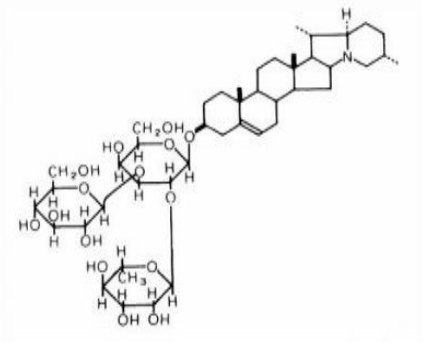

Figure 4. A typical saponin called solanine. Source: (36)

3.4. Oxalate

Oxalate (represented as $C_2O_4^{2-}$) is a metabolite present in plants, but when taken by humans it exerts the ability to form coordination with some entities such as Fe^{2+} and render the metals in question insoluble and unavailable for nutritional value. Iron oxalate is typically harmful owing to its nature of being crystals eliciting oxidative damage and starving red cells of hemoglobin (36,44).

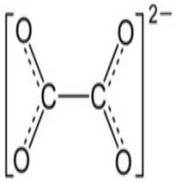

Figure 5. Oxalate anion. Source: (36)

3.5. Tannins

These are synthesized to make complex phenols that interfere with enzymes activities. They cause severe growth problem, and poor availability of dietary iron as well (36,39,42).

3.6. Hemagglutinins

Indirectly relates with iron metabolism by inciting agglutination of blood cells in human body system (36).

3.7. Goitrogens

Certainly, nitrates, bromide, fluoride, chloride, phosphate, cyanide, perchlorate etc are some specific goitrogens. Goitrogens naturally exists as substances that impede the activities or functions of the thyroid gland. The name goitrogens was coined because goiter is an enlargement of the thyroid due to concern. These plant materials are present in food materials like legumes, soy beans, vegetables etc (36). Goitrogens work diversely, for example, by affecting transporters that take iodine into cells, by impeding thyroid hormones, by affecting T4 or T3 making and increasing excretion of T4, among other ways (7, 18, 36).

4. Methods for relieving antinutrients of foods

4.1. Milling

Milling is utilized to get rid of the bran from grains, a technique that dispose off phytate, fibers, and specific minerals (33).

4.2. Soaking

Soaking is done for foods such as grains to aid fermentation or germination; and phytase affects the concentration of antinutrients phytate. It is a way that involves submerging grains or foods in aqueous medium for a given period of time (38).

4.3. Fermentation

Fermentation decreases the levels of antinutritional factors present in food materials and it involves microbes acting upon legumes, cereals to bring about synthesis; therewith, phytate, tannins, etc are neutralized (45).

4.4. Germination

Germination upon activation elicit endogenous enzymes that catabolized antinutrients, because ideally the stress-state that needs them is exhausted by the favourable conditions of germination (46).

4.5. Cooking and relatives

Coking, boiling, and use of autoclave are processes that involve an application of heat energy to get rid of antinutrients from cereals, vegetables, legumes, etc at appropriate temperatures boiling, cooking, and antinutritional factors (47,48).

5. Chemistry aids the relationship of ant nutrients and specific elements

Some metals react or relate using coordination with other entities. Coordination complexes otherwise regarded as compounds involved an integration of central metal ion with bonded ligands to form a specific geometry. The legends are ions or dipolar entities that deal in Lewis acid/base dealings. The ligands in a coordination complex deal in the order or halides S <O <N <N^+ <NO^+ < CO; and hard metals such as Fe^{3+} like hard ligand such as oxygen-based donors; whereas, soft metals such as Cu^+ like soft ligands, albeit exception may resurface (35,49).

Zinc functions in enzymatic dealings such as in the activities of ligases, synthases (responsible for C-C bond making), hydrolases, etc. Structurally, zinc is important to stabilize the tertiary structure of proteins in enzymes (eg, superoxide dismutase, alcohol dehydrogenase, cytochrome quaternary structures such as stored insulin. Genetically, zinc must be present in zinc fingers as transcription factors as well. Synaptic transmission is facilitated when zinc ions facilitate brain cells in the utilization of glycine neurotransmitter (51). However, all the stated presence of zinc is probably due to its coordination ability, therefore, coordination ability give room for chelation of the metal thereby making it unavailable (49).

Table 3. Types of coordination compounds

N	Type of compound	Nature
1	Parent complexes	Formed with one ligand
2	Mixes ligand complexes	Made with 2 or more ligands
3	Protonated complexes	Contained protonated ligands
4	Deprotonated complexes	Deprotonation and coordination

Source: (35)

Table 4. Pairing of coordination entities in ant nutrients combination the micronutrients

First participant	Second participant
Soft acids	Soft bases
Intermediate acids	Intermediate bases
Hard acids	Hard bases

Source: (35)

6. Determinants to micronutrients problems

Illiteracy or poor knowledge

People that are knowledgeable about proper food combinations, treatments, processing are supposed to eat properly (52). However, due to poor knowledge people eat foods without diversification, and without appropriate processing strategies, thereby predisposing population to deficiencies (53).

6.1. Poverty

Poor people could not be able to afford good foods combinations, for example in developing countries or poor settings people eat low-quality foods due to poverty. In Nigeria, particularly foods are taken according to socioeconomic status of individuals and groups (54-56).

6.2. Famine and poor agricultural practices

Good agricultural activities ensure proper levels of soil and water nutrients for plant uptake to feed the food chain or food web. In places with deficient soils, plants are supposed to be deficient such as in arid areas and in turns leading to famine, hunger, and deficiencies (57).

6.3. Culture

Some people are biased to eating good foods because of culture, for example, some people are absolutely or apparently vegans that could increase intake of goitrogens and ant nutrients, as well as deprivation of consumers from other valuable essential nutrients (58,59).

7. Approaches for tackling the problems

7.1. Diversification of foods and nutrients awareness

There is need to use modern tools that reach out to all, especially in informing the rural and cultural people on how to simply consume food combinations and avoid cultural bias that affects proper nutrition. The practice of avoidance of immunization, improper weaning, avoidance of exclusive breastfeeding, etc should be forewarned. Parable, a food should be Quarimix (staple + animal protein + plant protein leafy vegetable), Triple mix (staple + animal protein or leafy vegetables), etc. Noteworthy, diversification of foods requires families, groups, individuals, and communities to be actively informed and motivated to actions (60-63).

7.2. Dietary amendment

In this approach, the food is an altered to give suitable contents such as in the case of salt iodization, iron supplementation, etc. Staple foods such as maize, rice, flour, vegetables, rice, sugar, salt, can be improved with nutrients to reach the general population (1,50).

7.3. Economic strategy

At this juncture, priorities should be given on the tips that improve economics of population suffering from micronutrients problems. Parable, assigning some work to population and consequently paying them with foods, giving subsidized foods, etc (4).

7.4. Nutritional surveillance

This method involves targeting the most affected member of the population by surveying their nutrition from time-to-time and rendering appropriate support when problems are detected (4,61).

8. Conclusion

The objective of this paper is to identify the implications of consumption of dietary antinutrients on selected micronutrients health in humans or relations. Micronutrients are inevitable nutrients such as minerals (Zn, Fe, I) needed to be consumed from diet and most be present in required amount for proper human body functioning. Due to the evolution of plants, they made some certain substances called antinutrients that when ingested by humans they spur a hurdle on the utilization of nutrients. On many occasions antinutrients contributed immensely to the development of deficiencies that are harmful to the body. The paper has successfully divulged some antinutrients such as oxalate, flavonoids, tannins that affect selected essential micronutrients such as Zn, Fe, and I. It is important to increase nutritional awareness among the public, so that rightful decisions are taken to circumvent the effects of dietary antinutrients.

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Authorship contribution

Yusuf Sarkingobir contributed by making Conceptualization, Data curation, and Formal analysis, while, Yusuf Yahaya Miya contributed Funding acquisition, Investigation, Methodology, Validation, Visualization, and Writing. The review and editing were done through collaboration.

Declaration of competing interest

There were no any conflicts of interest that could inappropriately influence or cause bias in this work.

Data availability

To foster transparency, there is availability of the entire data at submission.

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