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## REVIEW ARTICLE

# A Review on Antinutrients and Their Impact on Human Health

Darshita Sinha<sup>1</sup> and Munmi Borkataky\*<sup>2</sup>

<sup>1</sup>Department of Life Sciences, Dibrugarh University, Dibrugarh 786004, Assam, India

ORCID: <https://orcid.org/0000-0001-7966-6945>

Email-id: darshitasinha09@gmail.com

\*Email-Id: mbk139@gmail.com

### ABSTRACT

*Modern society has easy access to knowledge, allowing individuals to choose from a variety of foods and support a healthy lifestyle, whereas plant-based foods are becoming more significant as they are essential to a sustainable, low-meat, and nutritious diet. The quest for a sustainable green and healthy lifestyle necessitates several dietary choices. Nutrients have been linked to improved human health. Antinutrients, on the other hand, are significantly less popular among modern people. They are extremely bioactive, having both negative and positive health impacts on humans, and are widely accessible in plant-based meals. These antinutrients, which can be of both natural and synthetic origin, reduce the body's capacity to absorb vital nutrients. A high concentration of antinutrients in the body can cause vomiting, bloating, migraines, dermatitis, nutritional deficits, and other symptoms. Some well-known antinutrients are phytates, oxalates, and lectins. The main objective of this study is to summarize the availability of different antinutrients in certain foods, to clarify their influence (both beneficial and harmful) on the human body, and to highlight different reductional strategies to disable them. This review includes references to the relevant literature as well as a thorough overview of newly published research on plant-based antinutrients.*

**Keywords:** Food security, Antinutrients, Minerals, Food processing.

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### INTRODUCTION

In recent years food security becomes a major issue all over the world. Population, exploration and reduction in food production due to habitat degradation and climate changes are the related issues to food security. In the case of the Global Hunger Index, India ranked at 107 positions out of a total of 121 countries. The need of the hour is to search for every alternative to mitigate the problem of food and nutritional deficiency. Humans primarily had a barbaric existence throughout the Paleolithic era, scavenging for the majority of their sustenance. They went hunting for food rather than cultivating for themselves. This led to an unhealthy lifestyle as their limit to consume more calories and proteins was exceeded. When compared to the generation before it, individuals in modern culture have easy access to information, allowing them to pick from a range of meals and promote a healthy lifestyle [41]. So scholars assumed that the switch in diet occurred along with these evolutionary changes. Food serves as a fuel that gives an organism the nutritional support it needs to survive. It may be derived from plants, animals, or fungi and include vital components known as nutrients. The elements in food known as nutrients are what organisms need to survive, develop, and reproduce. Understanding how each component, including carbohydrates, protein, fats, vitamins, minerals, and water, works is crucial. Through the intake of a balanced diet, this nutritional equilibrium can be achieved. Food quality should be the main concern rather than food sufficiency. However, some substances referred to as antinutrients reduce the body's capacity to absorb vital nutrients. Therefore, to study the impacts of various dietary components on human lifestyle, reliable, thorough, and up-to-date information is required. Vegetables, fruits, grains, and legumes are examples of plant-based foods that are crucial components of the global human diet according to the Global Dietary Database 2010. For instance, the importance of certain food items is rising because of sustainability concerns. Plant-based meals make up a significant component of diets

worldwide, but especially in poorer nations [58]. In addition to providing macronutrients, plant-based food systems are the major source of micronutrients, such as minerals, which are described as chemical components needed by organisms to carry out essential tasks [33]. Due to the fact that the human body is unable to produce minerals, they are categorized as necessary nutrients [45]. However, new research and information suggested that eating whole grains, fruits, and vegetables might improve health and help manage chronic conditions including diabetes, cancer, and coronary artery disease [38, 14]. However, frequent use of these foods may also result in a higher intake of the antinutrients they contain [34,36]. In addition, low amounts of naturally occurring antinutrients found in cereals, fruits, and vegetables have been linked to positive health impacts [56].

Antinutrients are plant compounds that reduce the body's ability to absorb essential nutrients and micronutrients. These may be deleterious during periods of malnutrition, or among people who base their diets almost fully on grains and legumes. Poor bioaccessibility and bioavailability of minerals from plant-based foods might likely contribute to the high incidence of mineral deficiencies, together with inadequate dietary intake and consumer physiological state (such as malabsorption and sickness) [45]. However, antinutrients are not always considered harmful they may also exert some beneficial health effects at low concentrations. The mechanisms to regulate adverse and beneficial effects of food antinutrients are the same. Thus, different processing conditions to remove certain unwanted components of foods are mandatory. These concentration-dependent effects may be manipulated in such a way that certain advantages can be obtained from their health-related benefits so that different chronic diseases can be demolished [48]. Different compounds from food legumes have been shown to cause physiological and biochemical effects and are the source of protein and carbohydrates in the human diet. Due to the presence of some antinutritional substances nutritive values decreases [44]. These compounds include phytic acid, condensed tannins, polyphenols, protease inhibitors (trypsin and chymotrypsin),  $\alpha$ -amylase inhibitors, lectins, oxalate, etc. This review article focuses on the disparity between the mineral content and the amount of minerals that can be released and absorbed from plant-based foods during human digestion. This review study also outlines how various processing methods (such as milling, soaking, dehulling, fermentation, germination, and thermal processing) affect the bioaccessibility and bioavailability of minerals in plant-based diets.

#### **Major Antinutrients in plant food:**

##### **PHYTATE**

Phytic acid, a compound found in as components in varying concentration in the cotyledon of legumes, oil seed, bran region of cereal grains etc in the form of phytin or phytate salts [88]. Because of its highly negatively charged structure it is a very reactive compound which leads to the attraction of the positively charged ions such as those of zinc and calcium, for which it is considered to be a food antinutrient and its removal is considered important during food processing [10, 26]. Phytic acid may also react with charged groups of protein and with starch molecule. Such binding may lead to reduction of solubility and digestibility of proteins and starch components [19]. Phytates inhibit different digestive enzymes like pepsin, trypsin, amylase etc [54]. Moreover, beside these potential beneficial effect of phytic acid is also remarkable. It helps to lower the blood glucose response to starchy food. This is because of decrease in the rate of starch digestion. Removal of it can increase the blood glucose level and insulin concentration which leads to reduce stimulus for hepatic lipid synthesis<sup>55</sup>. It has also been seen to reduce the plasma cholesterol and the levels of triacylglycerols. Another potential and beneficial effect is their protective influence against cancer [29]. A significant reduction in the numbers and size of tumours is reported in the presence of phytic acid [49].

##### **TANNIN**

The bitter-tasting polyphenolic molecules in food are known as tannins [42]. The tannins in tea are what cause the tongue to feel dry after drinking a strong tea. Although several compounds with the same characteristics are classified under the same name<sup>40</sup>, a tannin molecule with 10 galloyl groups bound to glucose is often considered as tannic acid. Structure-based classification of tannins: (i) Plants have hydrolyzable tannins, which can be broken down into phenolic acids and carbohydrates. gallotannins and ellagitannins, which both have gallic acid as their basic building block. (ii) Polymers of the flavan-3-ols found in plants make up condensed tannins. Under oxidative circumstances, they depolymerize into proanthocyanidins, which are anthocyanidins. (iii) Lower molecular weight phenolic compounds are pseudo tannins. Tannins are phenolic and secondary compounds which are formed in different plant parts like leaves, bark and fruits. Gallic acid and flavan-3-ols, the building blocks of tannins, were identified in plants in distinct concentrations. (iv) Brown algae contain phlorotannins, which are oligomers of phloroglucinol [39]. They are precipitate proteins and usually affect protein digestibility and also in reduction of essential amino acids. Plant tannins are found mainly in beverages, in fruits like

pomegranate, berry fruits and are also found in cereals in concentrated manner. Naturally, there are two types of tannin groups- hydrolysable and condensed. Hydrolysable tannins are gallotannins and ellagitannins and condensed form are proanthocyanidin, which are mainly found on leguminous, forage and some seeds [4].

#### **SAPONIN**

Saponins are plant derived surface active secondary metabolite compound that is made of a steroid (or triterpene) group attached to a sugar molecule in a compound [41]. When present in high concentration in food, it becomes toxic and give bitter taste which affect nutrient absorption by inhibiting the metabolic and digestive enzymes as well as tie up nutrient such as zinc [41]. They are naturally foam producing compound (triterpene or glycosides) by many plant species. Saponins have some valuable biological effects due to their powerful surface activity. It is found that saponins show high hypocholesterolemic effect in the presence of cholesterol [41].

#### **LECTIN**

Lectins and Haemagglutinins are proteins which are abundantly found in plant foods that are often taken in raw form. Some lectins are toxins such as jack beans, winged beans, mung beans etc. when it's consumed orally. But lectins found in soya beans and peanuts are not toxic as compared to them. When lectins are consumed through food, it inhibits the utilization of nitrogen and protein in the small intestine which proceed to colon formation. They are also found to affect different mineral metabolism [41].

#### **TRYPSIN INHIBITORS**

A trypsin inhibitor is a protein that is found to reduce the biological activity of the trypsin and chymotrypsin in the gut which leads to prevention of protein digestion. They are found in wide ranges of food but are mainly found in the families of leguminosae, solanaceae and poaceae families [41]. The most important species under these families are chick peas, red kidney beans, mung beans etc. The antinutrient activity of trypsin inhibitors shows growth inhibition and Pancreas hypertrophy [37].

#### **ALPHA- AMYLASE INHIBITORS**

Alpha-amylase inhibitors are those substances that inhibit the starch metabolism, therefore reducing the availability of carbohydrate that serve as energy resource for those organisms feeding on plants. After amylase binds with a-amylases the function of a-amylase becomes inactive which leads to inactivation of different activities by salivary and pancreatic amylases [21]. As a result of which reduction in the growth and metabolism of animals is seen. However it has certain beneficial uses as it seen to be used in the treatment of obesity and diabetes for example kidney beans are rich in a-amylase inhibitors. It is also found that a-amylase inhibitors are used in protecting the seeds against microorganisms and pests [61].

#### **GOITROGENS**

Goitrogens get their name from the term "goiter". These are some naturally occurring substances that inhibit the function of thyroid gland causing difficulty for the gland to synthesize its hormones and work properly. This caused the gland to enlarge to compensate for this inadequate hormone production. As goitrogens interfere with iodine uptake this iodine deficiency leads to the sensitivity of the thyroid gland to goitrogens [12].Vegetables from the genus *Brassica* are considered to be goitrogenic, as they are some of the goitrogen rich foods which includes broccoli, cauliflower, cabbage and different crucifers [15].

#### **OXALATES**

Oxalates are antinutrients that are found to be present in leafy greens and other plant foods [25]. It is an organic compound that is found in plants, which usually bound to minerals and form oxalate. Both the term oxalic acid and oxalate are interchangeable. Oxalate binds to minerals in the gut and prevents the body to absorb them. However too much of oxalic acid consumption have deleterious effects on human nutrients causing Kidney stone. Some of the high oxalic acid foods are fruits (berries, kiwis, figs etc.), vegetables (potatoes, okra, peanut etc), nuts (almonds, peanut) and different varieties of legumes [41].From the above study it can be seen that how nutritional value of foods strongly depends on anti-nutrients present in different plant based food.

#### **REDUCTION STRATEGIES OF ANTINUTRIENTS**

It is well known that anti-nutrients have a significant role in the reduction of various minerals and nutrients from food as a result of which it makes them toxic, when taken in higher concentration in the diet. Due to this reason various reductional strategies of antinutrients in the food have been found, which makes the non-conventional food in the conventional one. Different traditional methods and techniques such as soaking, cooking, milling, debranning, roasting, heat treatment, chemical treatment, traditional smoker, radiation and fermentation have been used to reduce these above mentioned antinutritional components found in food. These methods and techniques are being discussed below:

### Soaking

Soaking is one of the simple domestic methods that are used in the removal of antinutrients from food. It is good to get into the practice of soaking foods like legumes, grains, quinoa, corns etc. before cooking which will help to improve the nutrient value of food [46]. Since many antinutrients are soluble in water they simply get dissolved when the foods are soaked. For instance it has been found that when peas are soaked for 12 hours, 9% of phytate content is reduced [11]. Another study found that when pigeon peas are soaked for 6-18 hours it decreases lectins by 38-50%, tannins by 13-25% and protease inhibitors by 28-30% etc<sup>3</sup>. Soaking usually provides the needed moist conditions which are required in germination. Soaking is typically used in combination with other methods like sprouting, fermentation, cooking [1, 47]. It increases the hydration levels of different seeds, legumes thus making them soft and releasing different enzyme inhibitors and antinutrients. When the foods are soaked in distilled water, salt solution, 1% sodium bicarbonate, it has been found to reduce the amount of antinutrients like phytates, protease inhibitors, phenols, tannins, oxalates, lectins etc. higher and longer periods of soaking reduced phytic acid. Along with the decrease in antinutrients it has found to show equal improvement in protein digestibility and starch digestibility which ultimately means more energy can be used [58, 59].

### Sprouting/ Germination

Sprouting is the pioneer stage of plants where the plants start to emerge from seeds. This is a natural process which is also known as germination. It has multiple health benefit and considered to be one of the most effective processes in reducing antinutrients such as phytate levels and protease inhibitors [41]. It was reported that sprouting significantly reduced the content of phytic acid and polyphenols of mungbean seeds and along with it improved the protein and starch digestibility [30]. However the content of antinutritional components were determined after germination where they found that phytic acid and tannins were reduced by 18%-21%, this results showed that more temperature in germination leads to more biodegradation of phytates and trypsin inhibitors<sup>47</sup>.

### Fermentation

Fermentation is also considered to be one of the useful strategies to increase the nutritional quality of food<sup>22</sup>. It is actually a process of converting carbohydrates such as starch or a sugar into an alcohol or an acid. It occurs when microorganism start digesting carbs from food [53, 60]. Several reports have shown to reduce the contents of different antinutrients which include phytic acid, tannins, and protease inhibitors. It is reported that fermentation is an efficient processing method to remove phytate which increased the amount of soluble iron, zinc, calcium [36] It was reported that lactic acid fermentation results to reduction of tannin levels [43]. When fermentation of germinated millet sprouts were performed at temperature 30°C in the presence of a mixtures of probiotic culture that consisted the *Saccharomyces diasticus*, *Saccharomyces cerevisiae*, *Lactobacillus brevis* and *L.fermentum* for 72 hours, it was found that approximately 88.3% phytic acid content was reduced [32]. Another study was performed to show how microbial fermentation effect on antinutritional composition of local cassava products. It was found that it significantly decreased the amount of cyanide by 86%, tannins by 72%, phytates by 72%, oxalate by 61% and saponins by 92%. Moreover it was reported in a study that more is the period of fermentation more will be the reduction in the levels of antinutrients [20].

### Heat treatment

Heat treatment which includes cooking, autoclaving, and sun-drying is one of the effective applications in increasing the nutrient value of food by reducing antinutrient levels [31]. Studies showed that oven drying and sun drying of leaves is effective processing methods in removing polyphenols and 60% phytates respectively [2, 7]. It was reported that domestic process and cooking method including soaking, ordinary and pressure cooking of soaked and unsoaked seeds significantly lowers phytic acid, saponin and polyphenols of mungbean seeds [5]. Increase in the period of pressure cooking was more effective in reducing saponin and polyphenols than phytic acid. After working on removal of antinutrients from kidney beans, it was observed that, due to the heat sensitive nature saponin, trypsin inhibitor and phytohaemagglutinin diminish drastically to undetectable amount when heat process were employed [7]. Study on white and black variety of *Mucuna pruriens* var. utilis were performed where the results showed that cooking or autoclaving of both raw seeds and pre-soaked seeds in different solution (water, turmeric extract, sodium carbonate and citric acid) significantly reduced the content of total phenolics, phytic acid, trypsin inhibitor and chymotrypsin inhibitor activities [52].

### Milling

Milling is a process by which legumes are generally milled to remove their out coat which is known as husk by wet and dry process. Other names for milling are dehulling and debranning [62, 6] while performing an experiment to show the effect of cereals milling found that after milling, the rate of protein digestibility was increased for over 65% and a significant decrease of phytic acid was observed. The

digestibility of minerals was raised for all green samples. It is reported that phytic acids and tannins were drastically reduced by 18-21% and 20-38% respectively on dehulling over germinating sample [22, 23].

### Radiation

Among all the radiation gamma- radiation appeared to be one of the most effective processes in decreasing the levels of antinutrients such as trypsin inhibitor, phytic acid and oligosaccharides of Broad beans between 5-10% [1, 6]. Gamma- radiation is also applied as a safe post harvest method which helps in minimizing antinutrient of millet grains.

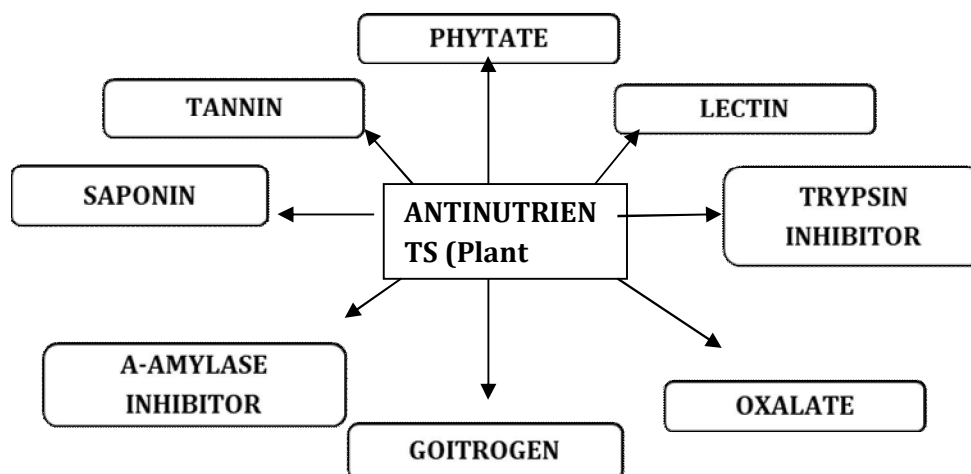


Fig.1. Major Plant originated antinutritional factor

Table.1. Beneficial properties shown by major anti-nutrients of plant-based foods

| Antinutrients       | Source  | Health benefits  |
|---------------------|---|--|
| Phytate             | Legumes, cereal grains, pseudo cereals (amaranth, quinoa, millet) ,nuts, seeds. | Apart from being an anti-nutrient, dietary phytate exhibits beneficial health effects, such as protection against a variety of cancer and heart-related diseases, diabetes mellitus, dystrophic calcification, renal stones, dental caries and dyslipidemia [17, 24]   |
| Tannin              | Tea, cocoa, grapes, berries, apples, stone food , whole grains etc.             | Tannins have also been reported to exert other physiological effects, such as to accelerate blood clotting, reduce blood pressure, decrease the serum lipid level, produce liver necrosis, and modulate immunoresponses. The dosage and kind of tannins are critical to these effects 9, 16].                                  |
| Saponin             | Legumes, pseudo grain, wheat, buck wheat, potato, tomato, egg plant, pepper     | Saponins decrease blood lipids, lower cancer risks, and lower blood glucose response. A high saponin diet can be used in the inhibition of dental caries and platelet aggregation, in the treatment of hypercalciuria in humans, and as an antidote against acute lead poisoning [50].   |
| A-Amylase inhibitor | Seeds, sesame, flaxseed, poppy, sunflower, pumpkin                              | Amylase inhibitors contain substances that prevent dietary carbohydrates from being absorbed by the body and may aid in weight loss. While some food and herbal extracts with amylase-inhibiting effects have shown promise in animal research, their benefits for type 1 diabetes await confirmation in clinical trials [23]. |

|                   |  |  |
|-------------------|--|--|
| Lectin            | Legumes, cereal grains, seeds, nuts, fruits, vegetables                            | In many large population studies, lectin-containing foods like legumes, whole grains, and nuts are associated with lower rates of cardiovascular disease, weight loss, and type 2 diabetes. These foods are rich sources of B vitamins, protein, fiber, and minerals, and healthy fats [27]. |
| Trypsin inhibitor | Legumes like soya, lentils, chickpeas and beans                                    | A trypsin inhibitor (TI) is a protein and a type of serine protease inhibitor (serpin) that reduces the biological activity of trypsin by controlling the activation and catalytic reactions of proteins [28].   |
| Oxalate           | Spinach, swiss curd, sorrel, beet greens, beet root, sweet potatoes, nuts, legumes | People who tend to form kidney stones may benefit from a low-oxalate diet. However, healthy people trying to stay healthy do not need to avoid nutrient-dense foods just because they are high in oxalates [13].   |
| Goitrogen         | Brassica vegetables (kale, brussel sprouts, cabbage, broccoli)                     | Goitrogens are compounds that interfere with the normal function of the thyroid gland. Put simply, they make it more difficult for the thyroid to produce the hormones your body needs for normal metabolic function [8].  |

## CONCLUSION

It must be kept in mind that the nutrients that are present in some form in food should be in the right quantity which is called as balance diet. Therefore the more we follow a balanced diet the more we sustain. Like ancient people says "take little and sustain forever". This review comes with some vital information regarding antinutrients, which plays an important role in hindering the absorption essential nutrients in food. These antinutrients which are mostly found in legumes, seeds, cereals etc brings complications for those choosing a complete plant based diets. However, when antinutrients are obtained in less concentration they are found to be effective in curing various diseases. The most common antinutrients present in plant, materials includes phytic acid, saponin, tannin, polyphenols,  $\alpha$ -amylase inhibitor etc. When these are present or obtained in higher concentration they seem to be harmful enough to cause many diseases like infertility, thyroid problems, indigestion of starch and proteins etc. Now-a-days several strategies are used to overcome the effects of antinutrients which include different sole techniques in disabling these antinutrients like soaking, germination, milling, radiation, heating, cooking, radiation etc. therefore different awareness programs must be organized on nutrition and antinutritional education among the people who are deprived from the world of education.

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