

Antinutritional Factors in Cereals

Abhishek Chitranashi¹, Aditi Mathur², Nandini GA¹, Mallesh Gampa¹, Ashok Kumar¹ and Diksha Srivastava³

¹Division of Biochemistry, ICAR-IARI, New Delhi

²Division of Pathology, Agriculture College Kota

³Division of extension education and communication management, RPCAU, Bihar

*Corresponding Author: chitranashiabhishek@gmail.com

Cereals like rice, wheat, and maize belong to the Graminae grass family, playing a crucial role as staple food crops globally. These cereal foods are vital components of daily diets, providing essential nutrients such as carbohydrates, proteins, dietary fibers, and vitamins. Epidemiological studies have highlighted the protective impact of whole grain foods against various diseases prevalent in westernized societies, including type 2 diabetes, cardiovascular diseases, and certain cancer.

Antinutrients encompass both naturally occurring and synthetic compounds that impede the bioavailability and absorption of essential nutrients. Research in nutrition predominantly investigates antinutrients prevalent in dietary sources and beverages. These entities can manifest as pharmaceutical agents, endogenous food-derived chemicals, proteins, or excessive intake of specific nutrients. Mechanistically, antinutrients operate by sequestering vitamins and minerals, thereby thwarting their assimilation, or by inhibiting enzymatic activities critical for nutrient metabolism.

Different types of antinutritional factors and strategies for its removal

Antinutritional factors (ANFs) represent a diverse group of naturally occurring compounds in various foods that can exert adverse effects on nutrient absorption and utilization in the human body. Understanding these factors is essential for developing dietary strategies that optimize nutritional intake and promote overall health. This comprehensive exploration will delve into the major antinutritional factors, their sources, effects, and potential mitigation strategies.

Phytic acid, identified as an antinutrient, diminishes mineral bioavailability, forming insoluble complexes with divalent cations. High polyphenol content in plant-based grains may also impede mineral absorption. Commonly found in grains, pulses, and seeds, phytic acid is concentrated in the

outer layers of cereals, comprising 1-2% of seed weight, reaching 3-6% in some cases. In maize, 90% is in the germ, while in wheat and rice, it is mainly in the pericarp and aleurone layer.

Folates, vital cofactors in enzymatic reactions, are pivotal for DNA integrity. Their deficiency heightens mutation and DNA breakdown risks, potentially leading to cancers. Adequate folate intake also lowers elevated serum homocysteine, a recognized coronary heart disease risk. Despite phenolic compounds' antioxidant properties, their complex formation with minerals reduces bioavailability, impacting iron and zinc absorption in cereal-based foods. This contributes to prevalent deficiencies, especially in infants, children, and women of childbearing age. Mineral absorption complexities extend to dietary content, influencing their bioavailability. The inefficiency of mineral absorption, particularly iron (below 1-30%), underscores the risk of malnutrition disorders due to dietary deficiencies.

Phytates, prevalent in cereals and legumes, serve as the main storage form of phosphorus. They chelate essential minerals, diminishing their bioavailability and posing a challenge to human nutrient absorption. Germination proves effective in reducing antinutritional factors like phytates, crucial for seedling development. However, the limited hydrolysis ability in humans results in an adverse impact on mineral bioavailability. Various factors, including genetics, environment, and soil conditions, influence the levels of phytic acid and phosphorus availability in cereal grains. Despite its role as a phosphate reserve during seed germination, phytic acid's complexation with metal ions, especially Zn (II), Ca (II), and Fe (III), categorizes it as an antinutrient, potentially leading to mineral absorption deficits with high consumption.

Strategies such as controlling phytic acid intake and germination have shown promise in reducing its levels and enhancing nutritional value.

Fermentation led to a significant reduction in total polyphenols and phytic acid content. Enhancing the nutritional quality of cereals requires the removal of undesirable components, a task achieved through traditional processing methods like fermentation and germination. Household techniques such as soaking, cooking, and fermentation significantly reduce levels of phytate and tannin, improving nutrient bioavailability. These processes, notably in fermented cereal products, lead to increased protein content and digestibility. In particular, finger millet benefits from germination and fermentation, reducing antinutrients and enhancing nutrient absorption. The reduction of phytic acid in pearl millet through fermentation highlights its nutritional potential.

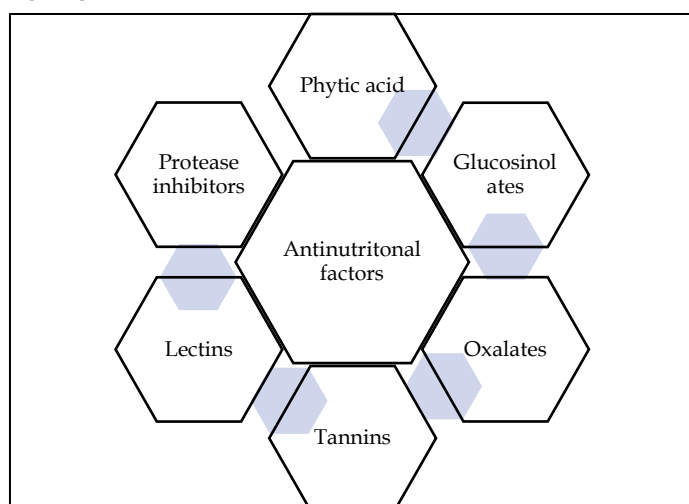


Fig 1. Different types of antinutritional factors present in plants

Phytic Acid

Phytic acid, or phytate, is a major antinutritional factor in wheat. Primarily concentrated in the bran and germ layers, phytic acid is the storage form of phosphorus in plants. Its strong chelating properties render phosphorus largely unavailable for human absorption, leading to reduced bioavailability of essential minerals like iron, zinc, and calcium. Source: Found in seeds, grains, and legumes.

Mitigation Strategies: Traditional food processing methods such as soaking, fermentation, and germination can effectively reduce phytic acid levels. These processes break down phytic acid,

releasing bound minerals and improving their absorption.

Protease Inhibitors

Wheat contains protease inhibitors that interfere with protein digestion. These compounds inhibit the activity of digestive enzymes involved in breaking down proteins, resulting in incomplete protein digestion and reduced availability of essential amino acids. Source: Present in various legumes and seeds.

Mitigation Strategies: Cooking and heat treatment are effective in reducing protease inhibitor activity. Proper processing of wheat products can minimize the negative impact on protein digestion.

Lectins

Lectins are carbohydrate-binding proteins in wheat that can interfere with nutrient absorption. They may bind to the lining of the gut, affecting the absorption of nutrients, and have been associated with inflammatory responses and autoimmune conditions. Source: Found in many plant foods, especially in grains and legumes.

Mitigation Strategies: Cooking and processing can partially reduce lectin levels. However, complete elimination is challenging, and individuals with specific sensitivities may explore alternative grains.

Tannins

Tannins, polyphenolic compounds present in the bran layers of wheat, can bind to proteins and minerals. This binding forms complexes that are less digestible and absorbable in the gastrointestinal tract. Source: Present in tea, coffee, some fruits, and grains.

Mitigation Strategies: Soaking, fermenting, and cooking can help reduce tannin levels in wheat-based foods, improving the bioavailability of nutrients.

Oxalates

While not as abundant, oxalates in wheat can bind with minerals, forming insoluble complexes. High oxalate intake may contribute to the formation of kidney stones in susceptible individuals. Source: Found in foods like spinach, rhubarb, and beet greens.

Mitigation Strategies: Cooking and boiling effectively reduce oxalate content in wheat products.

Adequate hydration and a balanced diet further help mitigate the risk of kidney stone formation.

Gluten

Gluten, a complex mixture of proteins in wheat, can trigger immune responses and damage the intestinal lining in individuals with celiac disease or non-celiac gluten sensitivity.

Mitigation Strategies: For those with gluten-related disorders, adopting a gluten-free diet is essential. This involves substituting wheat with alternative grains and carefully managing food choices to avoid gluten-containing products.

Alkaloids

Alkaloids, present in various plants, including potatoes, tomatoes, and certain spices, can be toxic and interfere with nervous system function. While some alkaloids, like caffeine, are well-tolerated, others may pose health risks in excessive amounts. Proper cooking and preparation methods are essential to minimize alkaloid content and potential toxicity.

Glycosides

Glycosides, found in certain plants like cassava, release toxic compounds upon ingestion, impacting digestion and nutrient absorption. For example, cyanogenic glycosides can release cyanide. Proper processing methods, such as thorough cooking, are crucial to reduce glycoside content and eliminate potential health risks.

Amylase Inhibitors

Amylase inhibitors, found in certain grains and legumes, interfere with the activity of amylase, the enzyme responsible for starch digestion. This interference may affect carbohydrate metabolism. Cooking and heat treatment are effective in reducing amylase inhibitor activity, ensuring better starch digestion.

Glucosinolates

Abundant in cruciferous vegetables like broccoli and cabbage, glucosinolates can interfere with iodine uptake by the thyroid gland and may have goitrogenic effects, potentially impacting thyroid function. However, these compounds also exhibit anticancer properties. Cooking and processing can reduce glucosinolate levels, making the balance

between potential benefits and risks an important consideration.

In addition to these individual antinutritional factors, it's crucial to consider their cumulative effects in a varied diet. The goal is not to eliminate these compounds entirely, as many also have beneficial properties, such as antioxidant and anticancer effects. Striking a balance between the potential risks and benefits requires an understanding of the specific dietary context, individual sensitivities, and appropriate food processing techniques.

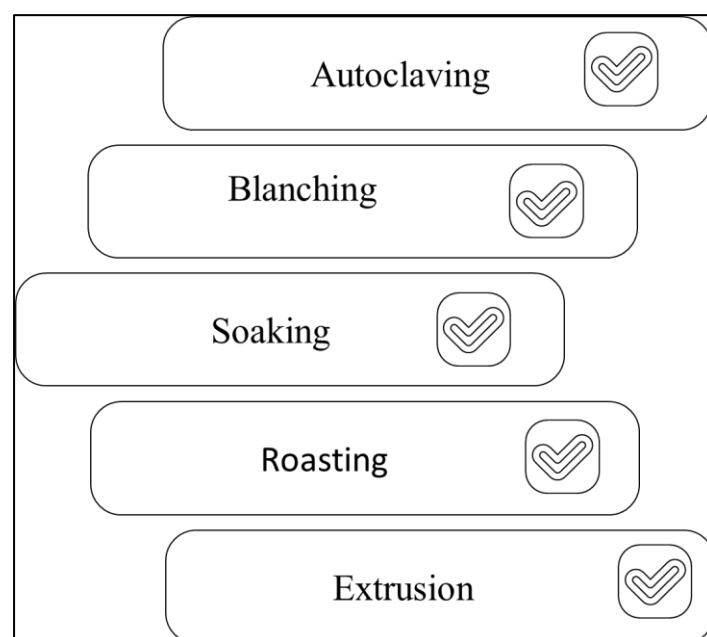


Fig 2. Different methods of Antinutritional factor removal

Furthermore, the nutritional quality of foods can be influenced by the interactions between antinutritional factors and the overall composition of the diet. For example, the presence of certain nutrients in the diet may mitigate the impact of antinutritional factors, emphasizing the importance of diverse and well-balanced dietary patterns. Research continues to advance our understanding of these factors, exploring innovative approaches to minimize their negative effects while preserving the nutritional value of foods. Additionally, individual tolerance and sensitivity to specific antinutritional factors can vary, highlighting the need for personalized dietary recommendations.

Conclusion

In conclusion, while antinutritional factors are inherent in many plant-based foods, their impact on health is complex and context-dependent. Proper food

processing, cooking techniques, and a diversified diet are crucial for minimizing the adverse effects of these compounds while ensuring the overall nutritional quality of the diet. Ongoing research and a nuanced understanding of the interplay between antinutritional factors and dietary components will contribute to the development of effective strategies for optimizing nutrition and promoting human health.

References

- 1) Adeyemo, S. M., & Onilude, A. A. (2013). Enzymatic reduction of anti-nutritional factors in fermenting soybeans by *Lactobacillus plantarum* isolates from fermenting cereals. *Nigerian Food Journal*, 31(2), 84-90.
- 2) Camargo, A. C., Favero, B. T., Morzelle, M. C., Franchin, M., Alvarez-Parrilla, E., de la Rosa, L. A., & Schwember, A. R. (2019). Is chickpea a potential substitute for soybean? Phenolic bioactives and potential health benefits. *International journal of molecular sciences*, 20(11), 2644.
- 3) Al Hasan, S. M., Hassan, M., Saha, S., Islam, M., Billah, M., & Islam, S. (2016). Dietary phytate intake inhibits the bioavailability of iron and calcium in the diets of pregnant women in rural Bangladesh: a cross-sectional study. *BMC Nutrition*, 2, 1-10.

* * * * *