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Antinutrational Factors in Plants, Potential Application and its Adverse Effect

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Abstract

Anti-Nutritional Factors (ANF) are chemicals that reduce nutrient utilization and/or food intake in plants or plant products used as human diets or animal feeds, and they play a key role in determining how humans and animals use plants. The goal of this review was to establish a baseline of knowledge on anti-nutritional factors in plants and their negative effects, as well as to clarify the impact of anti-nutritional factors in plants, testing methodologies, unfavourable effects, and prospective uses. Plants can be classified based on their chemical structure, specific activities they cause, or bio-synthetic origin. While this classification does not contain all anti-nutritional factors known to exist, it does include a list of those that are often found in human and animal diets. Heat stable anti-nutritional factors include phytic acid, alkaloids, tannins, saponins, and gluconosilates, while heat labial antinutritional factors include (lectins, proteinase inhibitors, cyanogens, -galactosides). Anti-nutrients in food cause a wide range of problems with nutrient and micro-nutrient absorption. Anti-nutrients, on the other hand, can be beneficial to your health in little doses. phytic acid, lectins, tannins, saponins, amylase inhibitors, and protease inhibitors, for example, have been demonstrated to restrict nutrient availability and inhibit growth. Phytate, lectin, tannins, amylase inhibitors, and saponins, when administered at low doses, have been proven to reduce blood glucose and insulin responses to starchy foods, as well as plasma cholesterol and triglyceride levels.

Keywords: Anti-Nutritional Factors (ANF); Plants; Adverse effect; Therapeutic potential; Human foods

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Introduction

Antinutrational factors are substances that reduce the nutrient utilization and/or food intake of plants or plant products used as human foods, and they are important in influencing how plants are used for humans. Antinutrational factors can also be defined as substances produced in natural foodstuffs by the normal metabolism of species and by various mechanisms (e.g. inactivation of some nutrients, diminution of the digestive process, or metabolic utilization of feed) that have an effect on how plants are used for humans [1,2]. Antinutrients are one of the most important factors that reduce the bioavailability of various cereal and legume components, as well as molecules that have evolved in plants for their own protection, among other biological activities, and limit the full use of nutrients, particularly proteins, vitamins, and minerals, preventing optimal nutrient exploitation and lowering nutritive value [1]. Antinutrational factors are substances that are produced in natural foods and/or feedstuffs as a result of a species' normal metabolism and a variety of mechanisms (such as the inactivation of specific nutrients, a reduction in the digestive process, or the metabolic use of food/feed) that have a negative impact on nutrition [3-5]. Anti-nutritional compounds found in most plants include alkaloids, tannin's, phytate, trypsin inhibitor, cyanogenic glycosides, cyanide, Saponins, and oxalates. Phytates and oxalates can form chelates with metal ions such as Cd, Mg, Zn, and Fe, resulting in poorly soluble compounds that are difficult to absorb *via* the digestive system, decreasing their bioavailability [6]. In addition to cyanogenic glycosides, food poisoning caused by plant secondary metabolites, also known as anti-nutritional factors, is common in poorer countries that rely heavily on vegetable-based diets. Many people have died as a result of illiteracy, starvation, and inadequate nutrition education, notably in African civilizations [4,5]. Vitamin and micro nutrient absorption are hindered by anti-nutritional compounds in diet, which can lead to organ failure. Anti-nutritional substances have also been found in plant-based diets. As a result, foods high in cyanogenic glycosides, enzyme inhibitors, lectins, tannin's, alkaloids, and saponins might harm people if consumed in large quantities. These substances' breakdown products may also have negative consequences [2,6]. Phytate, lectins, tannin's, amylase inhibitors, and Saponins have been shown to lower blood glucose and insulin responses to starchy meals, as well as plasma cholesterol and triglycerides when given in small doses [7]. Phytic acid, lectins, tannin's, Saponins, amylase inhibitors, and protease inhibitors, for example, have been shown to hinder growth and decrease nutrient availability. Phytates, tannin's, saponins, protease inhibitors, goetrogens, and oxalates have all been linked to a lower risk of cancer [8]. According to the literature review, plants contain a variety of anti-nutritional components that pose varied dangers to human health but are beneficial in small doses. This shows that, despite their lack of nutritional value, anti-nutrients may not always be harmful [5]. The aim of this review was to explain the impact of anti-nutritional factors in plants, as well as the methods of study, adverse effects, and possible applications, as well as to provide a baseline of information about anti-nutritional factors in plants and their negative effects.

Anti-Nutritional Factors

Anti-nutritional factors are chemicals found in animal feed or water that reduce the availability of one or more nutrients, either directly or indirectly through their metabolic products [6]. Plants include starch polysaccharides and non-starch polysaccharides, some of which are anti-nutritional [9]. Plants can be categorized according to their chemical structure, the specific activities they cause, or their biosynthetic origin [10,11]. Although this classification does not contain all known anti-nutritional factors, it does provide a list of those that are regularly present in human and animal feedstuffs [12,13]. Antinutrients are present in different food **(Table 1),** they have wide applicability **(Table 2)** but they also possess various adverse effects **(Table 3)**.

Table 1: Antinutrients in different foods [4].

Source	Type	Amount
Legumes (Soya, Lentils, Chick Peas, Peanuts, Beans)	Phytic acid	386 mg/100 g-714 mg/100 g
	Saponins	106 mg/100 g-170 mg/100 g
	Tannins	1.8 mg/g-18 mg/g
Grains (Wheat, Barley, Rye, Oat, Millet, Corn, Spelt, Kamut, Sorgho)	Phytic acid	50 mg/g-74 mg/g
	Oxalates	35 mg/100 g-270 mg/100 g
Pseudo-grains: Quinoa, Amaranth, Wheat, Buckwheat, Teff	Phytic acid	0.5 g/100 g-7.3 g/100 g
	Lectins	0.04 ppm-2.14 ppm
Nuts: Almonds, Hazelnut, Cashew, Pignola, Pistachio, Brazil Nuts, Walnuts, Macadamia, etc.	Phytic acid	150 mg/100 g-9400 mg/100 g
	Lectins	37 µg/g-144 µg/g
	Oxalates	40 mg/100 g-490 mg/100 g
Seeds: Sesame, Flaxseed, Poppy Seed, Sunflower, Pumpkin	Phytic acid	1 g/100 g-10.7 g/100 g
	Alpha-amylase inhibitor	0.251 mg/mL
Tubers: Carrot, Sweet potato, Jerusalem artichoke, Manioc (or tapioca), Yam	Oxalates	0.4 mg/100 g-2.3 mg/100 g
	Tannins	4.18 mg/100 g-6.72 mg/100 g
Potato, Tomato, Eggplant, Pepper	Phytic acid	0.82 mg/100 g-4.48 mg/100 g
	Tannins	0.19 mg/100 g

Table 2: Anti-nutritional factors and their potential application.

Antinutrational factors	Therapeutic potential	Reference
Tannin	Anti-carcinogenic, insecticidal, Antimicrobial, Anthelmintic, Hypocholesterolaemic and Anti-inflammatory activity.	[14-17]
Saponins	Anti-inflammatory, anti-diabetic, anti-HIV, anti-atherosclerotic and gastro-protective, anti-diabetic, anti-ulceractivities, immune stimulatory effects, management of arthrosclerosis, antimicrobial activity, hepatoprotective and hypo-lipidemic, lowering blood cholesterol, preventing peptic ulcer, and osteoporosis as well as platelet agglutination.	[18,19]
Phytate	Antioxidative effect, preventing pathological calcification, e.g. kidney stones and calcification in the heart vessels, cholesterol lowering effects anti-calcification effects and anticancer activity, plays an indispensable role directly or indirectly in several disease conditions, anti-diabetic, anticancer, anti-inflammatory properties to mention a few.	[20]
Alkaloids	Acting as attractant to promote pollination, antimalarial, Alzheimer's Disease (AD), Huntington Disease (HD), Parkinson's Disease (PD), Epilepsy, Schizophrenia, and stroke.	[21]
Lectins	Lectins manifest a diversity of activities including anti-insect activities, antitumor, immunomodulatory, antimicrobial and HIV-1 reverse transcriptase inhibitory.	[22]
Protease inhibitors	Antiviral Agents, cancer therapy, food preservative	[23-25]

Table 3. Important anti-nutritional factors and their adverse effects.

Anti-nutritional factors	Harmful effects	Dietary tolerable level	Amelioration techniques
Phytic acid	a) Protein, carbohydrate, and mineral intake and development are reduced, b) lower ash content in muscle, c) Skeletal deformity, d) Reduced thyroid function, e) Promotion of cataract formation, f) Abnormal pyloric caecal structure resulting in depressed absorption of nutrients, g) Increased mortality.	a) Carps, tilapia, trout, fish salmon and shrimp: <5 g/kg or <0.5%	a) Dietary phytase supplementation, b) Fermentation of feed ingredients yeast or lactic acid bacteria, c) Milling of outer layer, d) supplementation of mineral premix, e) Microwave irradiation & e-beam irradiation, f) The additional supplementation of Zn to prevent cataract, g) Aqueous extraction (18h) h) Moist heating (120oc for 2h).
Protease inhibitors	a)Pancreatic hypertrophy/hyperplasia, b) Reduced protein digestion and amino acid utilization, c) Reduced growth.	a) salmonids: <5 mg/g, b) nile tilapia: < 1.6 mg/g, c) carp: > 8.3 mg Ti/g, b) channel catfish: 2.2 mg/g	a) Moist heat treatment (autoclaving) for 15 min-30 min, b) Extrusion or steam cooking, c) Fermentation d) Germination e) Supplementation of essential amino acids, especially s-containing amino acids, to compensate the unavailable amino acids.
saponins	a) Reduce palatability and feed intake, b) Reduced feed efficiency & growth, c) Reduced reproductive performances, d) Respiratory distress, e) Death.	a) carp and other fish: <1 g/kg of diet, b) or name nttal fish: yet to be established.	a) Aqueous extraction but leaching of nutrients should be taken care of b) Extraction with ethanol, c) Cholesterol, supplementation.
Tannins	a) due to undesirable bitter taste they reduce palatability and feed intake, b) reduced feed efficiency & growth, c) damage of liver and kidney lead to death.	a) Ruminants: up to 15000 mg/kg feed (1.5%), b) Laying hens: up to 10000 mg/kg feed (1%), c) Rabbit: up to 10000 mg/kg feed (1%), d) Pig: up to 1500 mg/kg feed (0.15%) e)up to 15 mg/kg feed is safe for all animal species	a) Dehulling of seeds to remove the tannin-rich outer layer b) Treatment with alkali c) Treatment with ferrous sulphate (oxidising agent) d) Treatment with tannin complexing agents poly ethene glycol e) Soaking and drying and heat treatment (autoclaving) f) Fermentation with lactic acid bacteria g) Microwave radiation and e-beam irradiation.

oxalate or oxalic acid	a) Formation of calcium magnesium oxalate stones in the kidney concomitant kidney failure b) Growth and immunity depression	Ruminants <2% dietary oxalates and for non-ruminants <0.5% to avoid oxalate poisoning	Heat treatment

Tannins

The word tannin has a long history and refers to a traditional process. In the scientific literature, the term "tanning" was used to describe the process of converting raw animal hides or skins into long-lasting, non-putrescible leathers by applying plant extracts from various plant components [14,26]. Tannin is a bitter, astringent polyphenolic molecule found in plants that binds or precipitates proteins, amino acids, and alkaloids [14,15]. The term tannin is often used to refer to any large polyphenolic compound with enough hydroxyl and other suitable groups to form strong complexes with proteins and other macro molecules; however, the term is more broadly used to refer to any large polyphenolic compound with enough hydroxyl and other suitable groups to form strong complexes with proteins and other macro molecules [15,16]. Tannins have molecular weights ranging from 500 to over 3000 [27]. Tannins are heat stable, and they reduced protein digestibility in animals and humans, most likely by rendering protein partially inaccessible or blocking digestive enzymes, resulting in an increase in feces nitrogen [15,27]. Tannins are known to be found in food items, inhibiting the actions of trypsin, chymotrypsin, amylase, and Lipase, lowering food protein quality, and interfering with dietary iron absorption. Tannins have been linked to lower feed intake, growth rate, feed efficiency, and protein digestibility in laboratory animals [14]. If tannin levels in food become too high, microbial enzyme activities, such as cellulose and intestinal digestion, may be hindered. Tannins also form insoluble complexes with proteins, which may be responsible for the anti-nutritional effects of tannin-containing diets [16,27].

Classification of tannin

Condensed tannins and hydrolysable tannins are the two types of tannins. Despite the fact that condensed tannin is undoubtedly more important than hydrolysable tannin, little is known about its structure and many features remain unclear [17]. Condensed tannin's and hydrolysable tannins are the two types of tannins. Despite the fact that condensed tannin is undoubtedly more important than hydrolysable tannin, little is known about its structure and many features remain unclear [28]. In the leather processing industry, they have been employed to manufacture higher-quality leather. Hydrolysable tannin, on the other hand, is an ester of sugar and phenolic acids or their derivatives, with the sugar usually being glucose, though polysaccharides have been reported in rare circumstances [13,29]. During extraction and purification, hydrolysis, whether acidic, basic, or enzymatic, occurs frequently. Ellagitannin and gallo tannin are two kinds of ellagitannin. Ellagitannin possesses a hex hydroxyl diphenyl ester group, which distinguishes it from espolygalloyl esters [30]. Ellagitannin is broken down to produce ellagic acid and other phenolic chemicals such chebulic acid and chloro ellagic acid. Ellagitannin can be found in a variety of foods, including myrobalans, pomegranate rind, rose apple, and others. Gallic acid is produced when gallo tannin is hydrolyzed, making it a hydrolysable kind [30,31].

Phytate

Also known as Inositol hexa kisphosphate (InsP6). Plants, animals, and soil all contain phytate, which is a salt version of phytic acid. During the ripening stage, it accumulates in the seeds as a salt of the monovalent and divalent cations K^+, Mg^{2+}, and Ca^{2+}. Plant seeds and grains contain phytate in quantities ranging from 0.5% to 5% (w/w) [32,33]. Non-ruminant animals have a hard time absorbing the phosphorus connected to phytate [11]. All seeds and possibly all plant cells contain phytate, or myoinositol hexa-kisphosphate, a phytic acid salt. It serves as a phosphorus and mineral storage facility, storing 60%-90 % of the plant's phosphorus [32,34]. In cereals, phytate can be found up to 80% in the aleuronic layer, but it can also be found in the germ, and the endosperm is almost phytate-free. During seed germination, phytate is hydrolyzed, releasing phosphorous as well as minerals like calcium, magnesium, and iron, making them available for seedling germination and development [34].

Anti-Nutritional effects of phytate

Increased consumption of whole grains and legumes is recommended by health authorities all around the world. Whole-grain foods are abundant in dietary fibre as well as a range of bioactive compounds, vitamins, minerals, and trace elements, making them valuable sources of dietary fibre [35]. Mineral bioavailability has been blamed on the high phytate content of these products. Organic acids, lactic acid, ascorbic acid, and proteins, for example, can aid to reduce mineral inhibition. Food processing, such as soaking, germination, malting, and fermentation, as well as the addition of the phytase enzyme, which hydrolyzes phytate, can all help to remove phytate under optimum conditions. The acidity of the dough is crucial for phytate breakdown during scalding and sourdough fermentation. Sourdough fermentation (10% sourdough, pH 4.4-5.0) is more effective than yeast fermentation in lowering phytate levels. The regular dough can be reduced by 65% of its phytate content after 8 hours of fermentation at 37°C, compared to 97% in sourdough [33]. The breakdown of phytate will result in enhanced mineral and trace element bioavailability [12].

Oxalate

An Oxalate is a salt generated from oxalic acids, such as calcium oxalate, which has been discovered to be widely dispersed in plants. Oxalic acid forms strong connections with a variety of different minerals, including calcium, magnesium, sodium, and potassium [35]. This chemical combination results in the formation of oxalate salts [36]. Some oxalate salts, such as sodium and potassium, are soluble, but calcium oxalate salts are insoluble. When levels of insoluble calcium oxalate are high enough, it tends to precipitate (or solidify) in the Kidneys or Urinary tract, generating sharp-edged calcium oxalate crystals. These crystals play a role in the formation of kidney stones formation in the urinary tract when the acid is excreted in the urine [36,37]. However, it comes into contact with nutrients in the gastrointestinal tract when it is processed or digested. When oxalic acid is released, it binds to nutrients and makes them available to the body [35,37].

Anti-nutritional effects of oxalates

Oxalates, which act as a metabolic end product in humans, have no health benefits. Because oxalates cannot be further digested by humans, they must be eliminated in the urine once they are created by human metabolism or consumed from meals [38]. Because of their potential to chelate minerals, oxalates have negative effects on human nutrition and health. As a result, mineral bioavailability declines [36]. Oxalosis and increased urinary oxalate excretion are caused by a high diet of oxalate-rich foods. Calcium oxalate crystallization and kidney stone development can be caused by increased urine oxalate excretion [37]. Kidney stones are made up of calcium oxalate in 75% of cases. Calcium oxalate, being an insoluble compound, can pass through the digestive tract without being absorbed and precipitate in the urine. The ingestion of approximately 5 gm oxalic acid in crystal or solution is the minimum dose capable of causing death in human beings and is usually associated with corrosive gastroenteritis, shock, convulsive symptoms and renal damage [39]. Oxalic acid and its salts are metabolic end-products found in a variety of plant tissues. Because oxalates bind calcium and other minerals, eating these plants may have negative consequences. While oxalic acid is a normal end product of mammalian metabolism, consumption of additional oxalic acid may cause stone formation in the urinary tract when the acid is excreted in the urine [39]. The average daily oxalate consumption in English diets is 70 mg-150 mg, with tea proving to supply the most oxalate; rhubarb, spinach, and beet are other typical high-oxalate-content foods [36,38]. Vegetarians who eat more veggies have a higher oxalate consumption, which may limit calcium absorption [36,40]. This could be a higher risk factor for women, who require more calcium in their diet. Diets low in calcium and high in oxalates are not recommended in humans, although consuming high oxalate foods on occasion as part of a well-balanced diet is not harmful [4].

Saponins

Saponins are non-volatile, surface-active secondary compounds that are widely distributed in nature, especially in the plant kingdom. Since saponin molecules form soap-like foams when shaken with water, the term "saponin" comes from the Latin word "sapo," which means "soap'' [41]. They are structurally diverse molecules that are chemically referred to as triterpene and steroid glycosides. They consist of non-polar aglycone coupled with one or more monosaccharide moieties [2]. Their soap-like behaviour in aqueous solutions is explained by the combination of polar and non-polar structural elements in their molecules. Saponins have a variety of physical, chemical, and biological properties, including sweetness and bitterness, foaming and emulsifying properties, pharmacological and medicinal properties, hemolytic properties, antimicrobial, insecticidal, and molluscicidal activities, and antimicrobial, insecticidal, and molluscicidal activities [12]. Saponins are used in a variety of products, including drinks, confectionery, cosmetics, and pharmaceuticals [2]. Due to the presence of a lipid-soluble aglycone and water-soluble sugar chain(s) in their structure (amphiphilic nature), saponins are surface-active compounds with detergent, wetting, emulsifying, and foaming properties. Since saponins appeared to be highly harmful to fish and cold-blooded animals, and many of them had high hemolytic activity, they were classified as toxic. Saponins give dietary plants a bitter taste and astringency when present in high concentrations.

Anti-nutritional effects of saponins

Dietary saponins are extremely toxic to cold-blooded animals because of their hemolytic properties, which cause erythrocytes to rupture and release haemoglobin [18]. In ruminants, saponins were found to reduce nutrient utilization and conversion efficiency [10]. Saponin functions as a growth inhibitor in monogastric animals, reducing feed intake due to the bitterness and throat-irritating action of saponins. It reduces the digestibility of proteins by inhibiting digestive enzymes including trypsin and chymotrypsin [19].

Alkaloids

Alkaloids are a broad group of chemical compounds produced by plants and are typically found as salts of plant acids like oxalic, malic, tartaric, or citric acid [21]. Alkaloids are small organic molecules found in 15% to 20% of all vascular plants. They typically consist of several carbon rings with side chains, with one or more carbon atoms replaced by nitrogen. They are synthesized by plants from amino acids [12]. Amino acid decarboxylation generates amines, which react with amine oxides to form aldehydes. Mannich type condensation of aldehyde and amine groups forms the characteristic heterocyclic ring in alkaloids. Glycol-alkaloids (the glycone portion) glycosylated with a carbohydrate moiety, for example, are sub-classified based on the chemical form of their nitrogen ring. They are created as a result of metabolic processes [42]. The possible toxicity and bitter taste of alkaloids are usually repulsive to insects and herbivores. Because of their effect on the nervous system, alkaloids are considered anti-nutrients because they inhibit electrochemical transmission. Disruption of the cell membrane in the gastrointestinal tract is another toxicity [6].

Anti-nutritional effects of alkaloids

Humans are harmed by high levels of alkaloids, which cause toxicity and adverse effects, especially in physiological and neurological activities. Consumption of tropane alkaloids, for example, causes rapid heartbeat, paralysis, and, in the worst-case scenario, death. The ingestion of a high dose of tryptamine alkaloids will result in a stumbling gate and death [43]. On the other hand, distinguish between alkaloids' toxicity and their pharmaceutical effects. Lower doses of alkaloids, for example, mediate essential pharmacological activities such as analgesic, blood pressure reduction, tumour cell destruction, and circulation and respiration stimulation [21,42].

Lectins

Lectin comes from the Latin word “legere”, which means “to select”. Lectins are carbohydrate-binding proteins. The term "lectin" refers to proteins that can agglutinate red blood cells with a known sugar specificity. When the sugar specificity is uncertain, the term "hemagglutinins" is used. Lectins and hemagglutinins are proteins with at least one non-catalytic domain that binds to particular monosaccharides or oligosaccharides reversibly [22]. They can bind to the carbohydrate moieties on the surface of erythrocytes and agglutinate the erythrocytes, without altering the properties of the carbohydrates [2,31]. Lectins are glycol proteins found in legumes and some oilseeds (such as soybeans) that have an affinity for particular sugar molecules and are distinguished by their ability to combine with carbohydrate membrane receptors [44]. Lectins are carbohydrate-binding proteins found in most plants, especially seeds such as cereals, beans, and other legumes, tubers such as potatoes, and animals [45]. Lectins bind carbohydrates selectively, including the carbohydrate moieties of glycol proteins that adorn the surface of most animal cells [46,47]. They can trigger primary physiological reactions when ingested in abundance by susceptible individuals: they can cause significant intestinal harm, disrupting digestion and causing nutritional deficiencies; they can induce IgG and IgM antibodies, causing food allergies and other immune responses; and they can bind to erythrocytes, causing hem agglutination and anaemia, when consumed concurrently with immune factors. Lectins, in general, alter host resistance to infection, cause failure to survive, and even cause death in laboratory animals [22,45].

Function of lectin

Agglutination of cells and blood typing, Cell separation and analysis, Bacterial typing, Identification and selection of mutated cells with altered glycosylation, Toxic conjugates for tumour cell killing, cytochemical staining of cells and tissues, Mito-genesis of cells, Mapping neuronal pathways, Purification of glycoconjugates, Assays of glycosyltransferases and glucosidases, Defining glycosylation status of target glycoconjugates [44,46].

Anti-nutritional properties and adverse effects of lectin

For both humans and animals, some of these were discovered to be poisonous or anti-nutritional. The oral acute toxicity of lectins on humans is characterized by nausea, bloating, vomiting, and diarrhoea in general [46,47]. Loss of appetite, reduced body weight, and ultimately death is observed in laboratory animals fed plant lectin-rich diets [48]. Most lectins can bind epithelial cells that express carbohydrate moieties recognized by them because they are not degraded during their passage through the digestive tract [49]. This event is undoubtedly the second one in importance for determining the toxicity of orally fed lectins. Indeed, lectins that are not bound by the mucosa have little or no nutritive or harmful impact on consumers. When a lectin binds to the digestive tract, it may induce drastic changes in the cellular morphology and metabolism of the stomach and/or small intestine, as well as trigger a cascade of signals that alters intermediate metabolism [47]. As a result, lectins can affect cellular proliferation and turnover, as well as some or all of the digestive, absorptive, defensive, or secretory functions of the entire digestive system [4,8,48].

Inhibitors of Trypsin

The seeds of most cultivated legumes and cereals, for example, are widely dispersed in the plant kingdom [50]. Protease inhibitors are the most common form of anti-nutritional factor derived from plants. Protease inhibitors work by preventing proteolytic enzymes from working in the gastrointestinal tract of animals [44]. Protease inhibitors may be easily denatured by heat processing due to their unique protein nature, but some residual activity may still be present in commercially processed products [51]. Development inhibition and pancreatic hypertrophy are linked to protease inhibitors' anti-nutrient activity [51-53]. While lower incidences of pancreatic cancer have been identified in populations where soybean and its products consumption is high, the potential beneficial effects of protease inhibitors are unknown [45]. Protease inhibitors trypsin inhibitors and chymotrypsin inhibitors are found in raw legume seeds [54]. Many plant species, primarily grain legumes, contain trypsin inhibitors, which prevent protein digestion by inhibiting the activity of the enzymes trypsin and chymotrypsin in the gut [54,55]. Trypsin inhibitors are a special type of protein found in raw soybeans that bind to dietary protein and suppress protease enzymes in the digestive tract. Except in the presence of large quantities of digestive enzymes, these complexes are indigestible. Protease inhibitors block the action of trypsin and, to a lesser degree, chymotrypsin, impairing protein digestion in monogastric animals and some young ruminants [11,31]. Protease inhibitors have a regulating function; they inhibit endogenous proteases and are involved in the proteolytic self-regulation mechanism of the protein stored in the protein bodies before and during seed germination [56]. One way these compounds can prevent carcinogenesis is by lowering the protein digestibility and bioavailability of amino acids like Lucien, phenylalanine, and tyrosine, which are needed for cancer cell growth [3,23].

Anti-nutritional effects of protease inhibitors

Ingesting protease inhibitors from legumes has negative consequences. First, these compounds form inactive complexes with trypsin, lowering the levels of these free digestive enzymes, making proteolysis and amino acid digestion more difficult [24].

Enzyme-inhibitor complexes are also excreted, since they are high in sulfur amino acids [24,25]. Finally, these inhibitors induce pancreatic hypertrophy/hyperplasia due to chronic hypersecretion of the pancreatic enzymes trypsin and chymotrypsin), which causes sulfur amino acids that were previously used to synthesize tissue proteins to be diverted to enzyme synthesis [25]. All of this results in a decrease in essential amino acid levels, which affects animal growth habits and exacerbates an already critical situation with regard to sulfur amino acid deficiency in legume protein [23]. This secretion is thought to be regulated by a negative feedback mechanism, in which the endocrine cells of the duodenal mucosa release the hormone cholecystokinin when the content of trypsin/chymotrypsin in the duodenum falls below a certain level, prompting the pancreas to synthesize more serine-proteases [6]. Reduced levels of trypsin and chymotrypsin are released when ingested protease inhibitors enter the duodenum and form complexes with these digestive enzymes [2,49].

Conclusion

The Anti-Nutritional Factors (ANFS) may be defined as those substances generated in natural foodstuffs by the normal metabolism of species and by different mechanisms (e.g. inactivation of some nutrients, diminution of the digestive process, or metabolic utilization of feed) which exert effects contrary to optimum nutrition. Anti-nutrients are chemicals that have been evolved by plants for their defence, among other biological functions and reduce the maximum utilization of nutrients especially proteins, vitamins, and minerals, thus preventing optimal exploitation of the nutrients present in a food and decreasing the nutritive value. The anti-nutritional factors may be divided into two major categories. Proteins (such as lectins and protease inhibitors) are sensitive to normal processing temperatures. Other and which include, among many others, polyphenolic compounds (mainly condensed tannins), non-protein amino acids and galactomannan gums. More often than not, a single plant may contain two or more toxic compounds, generally drawn from the two categories, which add to the difficulties of detoxification. Several anti-nutritional factors are very significant in plants used for human foods and animal feeds. They are: Enzyme inhibitors (trypsin and chymotrypsin inhibitors), Saponins (soya sapogenin), Tannins (condensed and hydrolysable tannins). Amino acid analogues (BOAA, DAP, mimosine, N methyl-1-alanine), Alkaloids (solanine and chaconine), Anti-metals (phytates and oxalates). In general anti-nutritional factors are important for medicine, anti-oxidant, anti-inflammatory, insect side and plant defensive, industrial processing, gastro-protective, anti-diabetic animal and human food, but inappropriate consumption of those anti-nutritional factors to reduce the digestion of protein and mineral absorption that leads to different disease such as cancer, kidney stone accumulation, heart disease.

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