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ANTINUTRITIONAL FACTORS IN VEGETABLES

M.A. CHATTOO, S.H. KHAN, ANJUM ARA AND M.I. MAKHDOOMI

Division of Olericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, SRINAGAR (J&K) INDIA

There is a wide distribution of biologically active constituents throughout the plant kingdom, particularly in plants used in human nutrition. The knowledge that these compounds elicit both toxic and advantageous biological responses has given rise to several investigations in recent times as to their possible physiological implications in various biological systems.

It is well known that plants generally contain antinutrients acquired from fertilizer and pesticides and several naturally occurring chemicals. Some of these chemicals are known as secondary metabolites or antinutritional factors and they have been shown to be highly biologically active. They include saponins, tannins, alkaloids, trypsin (protease) inhibitors, oxalates, phytates, haemagluttinins, (lectins), cyanogenic glycosides, cardiac glycosides, coumarins and gossypol. The list is inexhaustible. Some of these plant chemicals have been shown to be deleterious to health or evidently advantageous to human health, if consumed at appropriate amounts.

The antinutritional factors (ANFS) may be defined as those compounds which reduce the nutrient utilization and/or food intake of plants or plant products used as human foods and they play a vital role in determining the use of plants for humans and animals.

Classification of the antinutritional factors: The antinutritional factors in plants may be classified on the basis of their chemical structure, the specific action they bring about or their biosynthetic origin. Although this classification does not encompass all the known groups of antinutritional factors, it does present the list of those frequently found in human food. In general the antinutritional factors found in plants are:

– Enzyme inhibitors (trypsin and chymotrypsin inhibitors, plasmin inhibitors, elastase inhibitors)
– Haemagluttinins (concanavalin A, ricin)
– Plant enzymes (urease, lipoxygenase)
– Cyanogenic glycosides (phaseolunatin, dhurrin, linamarin, lutaustralin)
– Goitrogens (pro-goitrins and glucosinolates)
– Oestrogens (flavones and genistein)
– Saponins
– Gossypol
– Tannins (condensed and hydrolysable tannins)
– Amino acid analogues (BOAA, DAP, mimosine, N-methyl-1-alanine)
– Alkaloids (solanine and chaconine)
– Anti-metals (phytates and oxalates)
– Anti-vitamins (anti-vitamins A, D, E and B12) and
– Favism factors.

Biochemical effects of the anti-nutritional factors:

The biochemical and toxicological/adverse effects of plant's secondary metabolites *i.e.*, anti-nutritional factors have been briefly summed up as follows:

– Cyanogenic glucoside on hydrolysis yields toxic hydrocyanic acid (HCN). The cyanide ions inhibit several enzyme systems, depress growth through interference with certain essential amino acids and utilization of associated nutrients. They also cause acute toxicity, neuropathy and death.

– Alkaloids cause gastrointestinal and neurological disorders. The glycoalkaloids, solanine and chaconine present in potato and *Solanum* spp. are haemolytically active and toxic to humans. Some of the toxicological manifestations of potato glycoalkaloids involve gastrointestinal upsets and neurological disorders.

– Tannins bind dietary protein and digestive enzymes to form complexes that are not readily digestible. They also cause decreased palatability and reduced growth rate.

– Saponins cause hypocholesterolaemia by binding cholesterol, making it unavailable for absorption. Saponins have also been demonstrated to have anti-spermal effects on human spermatozoa. They significantly inhibit acrosine activity of human sperms and the spermicidal effect is attributed to strong damage of the spermal plasma membrane. Saponins are characterized by bitter taste and foaming properties.

– Nitrate accumulation can have serious deleterious effects. Within the gastrointestinal tract nitrate (NO_3^-) is reduced to nitrite (NO_2^-) which is absorbed into the blood stream where it binds with haemoglobin oxidizing ferrous iron to ferric iron to form methaemoglobin. This form of haemoglobin complex is incapable of O_2 transport. The result is Anoxia, specifically referred to as methaemoglobinaemia.

– Trypsin (protease inhibitor) causes pancreatic

enlargement and growth depression. Haemagluttinins are proteins known for agglutinating red blood cells. They depress animal growth by interfering with the digestion and absorption of nutrients in the gastrointestinal tract.

– Phytates bind minerals like calcium, iron, magnesium and zinc and make them unavailable.

– Oxalates, like phytates, bind minerals like calcium and magnesium and interfere with their metabolism. They also cause muscular weakness and paralysis. Oxalates also cause gastrointestinal tract irritation, blockage of the renal tubules by calcium oxalate crystals, development of urinary calculi and hypocalcaemia. Oxalates cause nephrotic lesions in the kidney. Too much of soluble oxalate in the body prevents the absorption of soluble calcium ions as the oxalate binds the calcium ions to form insoluble calcium oxalate complexes. As a result of this, people with the tendency to form kidney stones are advised to avoid oxalate-rich foods.

– Gossypols are reported to cause animal and human toxicity and high incidence of irreversible testicular damage. Dietary gossypol can also bring about increased requirement, not only for lysine, but also for iron which it can chelate. At the physiological level, gossypol reduces oxygen availability in the blood. Other physiological abnormalities include hypertrophy and dilution of heart muscles and changes in electrocardiogram.

– Glycoalkaloids are reported to cause haemolysis and toxicity to humans. Some plant alkaloids are reported to cause infertility.

Antinutritional factors found in vegetables: Potato tubers, when exposed to unfavourable atmospheric conditions during storage, produce toxic constituents namely solanine and chaconine which are bitter in taste and have toxic effects when consumed in a significant quantity. Some leafy vegetables such as amaranthus, portulaca and basella contain appreciable quantities of oxalic acid. Calcium oxalate present in the form of fine crystals in the leaves of taro causes itching of the skin and a pricking sensation of the tongue and throat. The anthra-quinenones of rhubarb are mainly in the root, but human poisoning generally occurs from eating rhubarb leaves. The leaf poison is commonly thought to be oxalate, but other factors possibly the quinones are also involved. In terms of human lives lost from phenol originating in plants, salicylic acid is probably the most dangerous and is found in garlic, cauliflower, potato, tomato, capsicum, sweet potato, cabbage and rhubarb. This low molecular weight chemical has been found associated with hyperactivity in humans.

Cassava roots contain a toxic hydrocyanic glucoside, which on enzymatic hydrolysis liberates hydrocyanic acid. However, proper processing helps to reduce the levels of this toxic compound to safe level. Taro and Yam contain an acid substance, calcium oxalate crystals, which cause irritation to the tongue and mouth. This compound can be removed by cooking the roots in boiling water

Table 1 : Antinutritional compounds/toxicants of vegetables

Sr. No.	Vegetable	Toxic compounds	Adverse effects
1.	Carrot	Carota-toxin (polyacetylenic alcohol)	Neurotoxic symptoms
2.	Lettuce	Nitrates, Alkaloids	Methemglobinaemia
3.	Brassica (cruciferous vegetables)	Glucosinolates, Choline-esterase inhibitor, S-methyl cystiene sulfoxides	Goiter, Digestive disorders
4.	Beets, spinach	Oxalates, Nitrates, Phytate,Tanins, Saponins, Nitrosamine	Methemglobinaemia reduces bioavailability of certain minerals such as Ca, Fe and Zn. Carcinogenic
5.	Sweet potato	Ipomeamarone	Enzyme inhibitors
6.	Watermelon	Serotonin	Elevates Blood pressure
7.	Pumpkin and squashes	Choline-esterase inhibitor	Neurotoxic
8.	Legumes (vegetables)	Lectins,Cyanogenic glucosides, Haemagglutinins, Trypsin, Amylase, Glucose-6-P-dehydrogenase inhibitor, Compounds having anti-vitamin properities (Vitamin A,E and D)	Allergens
9.	Asparagus	Saponins, Choline-esterase inhibitor	Neurotoxic
10.	Solanaceous vegetables	Alkaloids	Birth defect, Protease inhibitor
11.	Potato	Solanine and Chaconine	Invertase inhibitor
12.	Tomato	Tomatine	Gastric discomfort
13.	Pungent pepper (chillies)	Capsaicin	Skin irritation, Gastric disorders
14.	Parsley, celery	Psoralens, Terpenoids, Alkaloids, Choline-esterase inhibitor	Dermatitis

and discarding the water. Some species of Dioscorea contain the toxic alkaloid dioscorine, which can be destroyed by roasting or boiling.

Peas and beans are known to contain certain antinutritional factors such as trypsin inhibitors, lectins, phytates and polyphenols.

Many cucurbit species contain compounds usually glycosides that impart bitter taste and at high levels are toxic. Pumpkins and squashes contain inhibitors of choline-esterase; water melon contains serotonin, which can cause elevated blood pressure. Some antinutritional compounds *viz.,* lectins have been detected in the phloem exudates of pumpkin, cucumber, muskmelon and snakegourd. A galactose specific lectin has been isolated from bittergourd. About a dozen trypsin inhibitors have been obtained from winter squash. Two protein biosynthesis inhibitors have been isolated from spongegourd. They are ribosome inactivating proteins. The common plant sterols β and sitosterol, stigmasterol, spinasterol and campesterol occur in most cucurbits. Several saponins have also been detected in cucurbits, particularly in Luffa and Tricosanthes. Tertiary and quaternary alkaloids have been detected in *Cucumis grandis* and snake gourd. Asparagus contains saponins and a choline esterase inhibitor. Tomatoes contain bitter tasting alkaloid tomatine. Pungent peppers contain the amide or resinoids or capsaicin.

The abundance of antinutritional factors and toxic influences in vegetables used as human foods certainly calls for concern. Therefore, ways and means of eliminating or reducing their levels to the barest minimum should be discovered which can be achieved by way of monitoring, enhanced public awareness and careful post harvest processing of these vegetables before consumption.