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Review on: Antinutritional factors in vegetable crops

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Abstract
Vegetables are an important source of protective food and a part of healthy diet. They contain chemical compounds, such as carbohydrates, sugars, proteins and vitamins, which are essential to human growth and health. In fact they make up for about 20% of an average Indian meal. However, plants generally contain toxic and anti-nutrients acquired from fertilizer and pesticides and several naturally occurring chemicals. Some of these chemicals are known as secondary metabolites or anti-nutritional factors and they have been shown to be highly biologically active. Anti-nutritional factor is known to interfere with metabolic processes such that growth and bioavailability of nutrients are negatively influenced. They include saponins, alkaloids, protease inhibitors, oxalates, haemaggluttinins (lectin), cyanogens, lethogens, and goitrogen. 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 in appropriate amounts.

Keywords: Antinutrient, vegetable, chemical, secondary metabolites, alkaloids

1. Introduction

Vegetables are the fresh and edible portions of herbaceous plants. They are important food and highly beneficial for the maintenance of health and prevention of diseases. They contain valuable food ingredients which can be successfully utilized to build up and repair the body. Vegetables are valuable in maintaining alkaline reserve of the body. They are valued mainly for their high carbohydrate, vitamin and mineral contents. There are different kinds of vegetables. They may be edible roots, stems, leaves, fruits or seeds. Each group contributes to diet in its own way (Robinson, 1990) [25]. Vegetables contribute minerals, vitamins, and fiber to the diet. Minerals are naturally occurring inorganic substances with a definite chemical composition and an ordered atomic arrangement. Among the plants, vegetables are the excellent sources of minerals and contribute to the RDA of these essential nutrients. These vegetables however contain antinutritional factors that can affect the availability of the nutrients. Scientists such as Fetuga *et al*., (1973) [11], Aletor and Aladetimi, (1989) [4] and Fowomola *et al*., (2007) [14] had studied and described the anti-nutritional factors of plant fruits and seeds. Anti-nutritional factors are those substances or chemical compounds found in fruits and food substances in general which are poisonous to humans. They reduce the ability of nutrients such as minerals, vitamins and even proteins within the plant material. This, in turn, affects the nutritional value of these plants. Anti-nutrients comprise of amino acids to proteins, simple amines to alkaloids, glycosides and phenolic compounds. When a plant food is consumed as a nutritional source, along with this, anti-nutrients are consumed and pose a health risk to the consumer (Ugwu & Oranye, 2006) [30]. Anti-nutritional factors are naturally-occurring compounds, present in different food substances in varying amounts depending on the kind of food, mode of its propagation, chemicals used in growing the crop as well as those chemicals used in storage and preservation of the food substances (Felix & Mello, 1990; Panhwar, 2005) [21]. These anti-nutritional factors are also known as 'secondary metabolites' in plants and they have been shown to be highly biologically active. These secondary metabolites are secondary compound produced as side products of processes leading to the synthesis of primary metabolites. Antinutrients are chemicals which have been evolved by plants for their own defense, they are produced by plants to defend themselves against fungi, insects and predators, and offer a protective mechanism for the plant. These anti-nutritional factors are known to interfere with metabolic processes such that growth and bioavailability of nutrients are negatively influenced (Abara, 2003; Binta and Khetarpau, 1997) [1, 5].

2. Types of Toxicants in Plant

The toxic 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 toxin, it does present the list of those frequently found in human food, in general the toxic substance in plants are:

- Cyanogenic glycosides (phaseolunatin, dhurrin, linamarin, lutaustralin)
- Enzyme Inhibitor (Alkaloids, protease inhibitors, cynogens,G-6-PD, cholinesterase inhibitors, amylose inhibitors)
- Physiological Disorganizors (lectines, saponins, lathrogens, oxalates, nitrate and nitrite)
- Alterations of Hormonal Actions (goitrogens) Antivitamins

2.1 Cyanogens

Some legumes like kidney bean, red gram and linseed cassava, and many fruit pits contain cyanogenic glycosides from which hydrogencyanide (HCN) may be released by hydrolysis (Akande.*et al.,* 2010) [2]. HCN can cause disfunction of the central nervous system, respiratory failure and cardiac arrest (D'Mello, 1989) [8]. Cyanogenic glucosides are classified as phytoanticipins. Their general function in plants is dependent on activation by b-glucosidases to toxic volatile HCN as well as a ketones or aldehydes to fend off herbivore and pathogen attack (Zagrobelny*, et al*., 2004) [32]. When plant material containing the glycoside is consumed, it is broken down by a b-glucosidase to produce a sugar and an aglycone. The aglycone is then acted upon by a hydroxynitrilelyase to produce cyanide and an aldehyde or a ketone. As cyanide is extremely toxic, one of the most obvious symptoms is death. In the body, cyanide acts by inhibiting cytochrome oxidase, the final step in electron transport, and thus blocks ATP synthesis. Prior to death, symptoms include faster and deeper respiration, a faster irregular and weaker pulse, salivation and frothing at the mouth, muscular spasms, dilation of the pupils, and bright red mucous membranes (Bjarnholt, 2008) [6].

Table 1: Hydrogen cyanide content in some food stuffs

Food	HCN (mg/100g)
Lima beans	210–310
Almonds	250
Sorghum sp	250
Cassava	110
Peas	2.3
Beans	2.0
Chick peas	0.8

2.2 Alkaloids

Alkaloids are the bitter components of plants found widely in nature and frequently have pharmacological properties. Mostly acting as secondary plant metabolites, alkaloids are often basic nitrogen–containing compounds able to form salts with acid (Watkins *et al.,* 2004) [31]. Alkaloids have been isolated from the roots, seeds, leaves, or bark of some members of at least 40% of plant families. Families being particularly rich in alkaloids include Amaryllidaceae, Compositae, Leguminosae, Liliaceae, Papaveraceae, and Solanaceae. Alkaloids Found in Plants and in Common Foods One type of alkaloid widely found in the plant kingdom is the pyrrolizidine alkaloids. These are chemicals found in as many as 6000 plant species or 3% of flowering plants. Other plant alkaloids such as the glycoalkaloids are found in common food plants acting like a natural pesticide against common pests. Common examples include solanine and tomatine. Solanine is an alkaloid present in small amounts in potatoes while tomatine is found in tomatoes. Alkaloids are considered to be anti-nutrients because of their action on the nervous system, disrupting or inappropriately augmenting electrochemical transmission. For instance, consumption of high tropane alkaloids will cause rapid heartbeat, paralysis and in fatal case, lead to death. Uptake of high dose of tryptamine alkaloids will lead to staggering and death. Indeed, the physiological effects of alkaloids have on humans are very evident (Fernando and Pathmeswaran, 2012) [12]. Alkaloids cause gastrointestinal and neurological disorders (Aletor, 1993) [3]. The glycoalkaloids, solanine and chaconine present in potato and Solanum spp. (Saito *et al*, 1990) [26] are haemolytically active and toxic to fungi and humans. Some plant alkaloids are reported to cause infertility (Olayemi, 2010) [20].

2.3 Protease Inhibitors

Protease inhibitors are widely distributed within the plant kingdom, including the seeds of most cultivated legumes and cereals. Protease inhibitors are the most commonly encountered class of antinutritional factors of plant origin. Protease inhibitors have the ability to inhibit the activity of proteolytic enzymes within the gastrointestinal tract of animals. Due to their particular protein nature, protease inhibitors may be easily denatured by heat processing although some residual activity may still remain in the produced products. The antinutrient activity of protease inhibitors is associated with growth inhibition and pancreatic hypertrophy. Potential beneficial effects of protease inhibitors remain unclear, although lower incidences of pancreatic cancer have been observed in populations where the intake of soybean and its products is high (Giri and Kachale, 2004) [15]. While protease inhibitors have been linked with pancreatic cancer in animal studies, they may also act as ant carcinogenic agents. The Bowman-Birk inhibitors derived from soybean have been shown to inhibit or prevent the development of chemically-induced cancer of the liver, lung, colon, oral and esophagus (Finotti *et al*, 2006) [13]. Trypsin inhibitor and chymotrypsin inhibitor are protease inhibitors occurring in raw legume seeds. Trypsin inhibitors that inhibit the activity of the enzymes trypsin and chymotrypsin in the gut, thus preventing protein digestion, are found in many plant species mainly in different grain legumes. Trypsin inhibitors are a unique class of proteins found in raw soybeans that inhibit protease enzymes in the digestive tract by forming indigestible complexes with dietary protein.

2.4 Favism

Favism is a disease characterized by haemolytic anaemia which affects certain individuals following the ingestion of fresh or cooked broad beans. The victims suffer from an inherited biochemical abnormality which affects the metabolism of glutathione in red blood cells and is the result of decreased activity of the enzymes glucose-6-phospate dehydrogenase. In person with his abnormality, the red cells are more prone to injury and destruction by certain drugs, such as sulphonamide and this raises complications in the treatment of infectious disease (Dmello *et al*., 1991) [9].

2.5 Lectines

Lectin comes from the Latin word "legere", which means "to select". Lectins have the ability to bind carbohydrates.

Nowadays, proteins that can agglutinate red blood cells with known sugar specificity are referred to as "lectins" (Fereidoon, 2014). Lectins Also called phytohaemagglutinins are proteins or glycoproteins of non-immune origin which have multiple highly specific carbohydrate binding sites (Pusztai, 1989) [24]. They were originally identified in the castor bean but are now known to be wide spread in the plant kingdom including grain products. Lectins are particularly concentrated in legume seeds and have been shown to cause gastroenteritis, nausea, and diarrhoea in human. Many types of beans contain lectins including green beans, red kidney beans and white kidney beans. Symptoms of acute toxicity include severe stomachache, vomiting and diarrhoea. Lectins can destroy the epithelia of the gastrointestinal tract, interfere with cell mitosis, cause local haemorrhages, damage kidney, liver and heart and agglutinate red blood cells. Lectins reduce the bioavailability of nutrients, which is due to direct action of lectin on digestive enzymes (Jindel *et al*., 1982) [18].

2.6 Saponins

Saponins are water-soluble plant constituents, which can form soapy foam even at low concentrations. They are glycosides with a non-sugar aglycone portion which is termed a sapogenin. Saponins are distinguished by their bitter Taste, and ability to haemolyse red blood cells. They are classified according to the chemical nature of the sapogenin into two major groups: steroidal and triterpenoid saponins. Saponins are widely distributed in the plant kingdom and can occur in all parts of plants, although the concentration is affected by variety and stage of growth. They are found in soybeans, sugar beets, peanuts, spinach, asparagus, broccoli, potatoes, apples, eggplants, alfalfa and ginseng root (Price *et al.,* 1987) [23]. Saponins are capable of disrupting red blood cells and producing diarrhoea and vomiting. Saponins reduce the uptake of certain nutrients including glucose and cholesterol at the gut through intraluminal physicochemical interaction. Hence, it has been reported to have hypocholesterolemic effects (Esenwah and Ikenebomeh, 2008) [10]. Saponins have also been demonstrated to have anti-spermal effect 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. (Su and Guo, 1986; Pant *et al*., 1989) [29, 22].

2.7 Lathrogens

Lathyrogens, found in legumes such as chick peas and vetch, are derivatives of amino acids that act as metabolic antagonists of glutamic acid, a neurotransmitter in the brain. When lathyrogens are ingested in large amounts by humans or animals, they cause a crippling paralysis of the lower limbs and may result in death (Shibamoto and Bjeldanes, 1993) [28]. Lathyrism only occurs on a impoverished diet of vetch, sweet pea, or grass pea and is characterized by bone thinning and leg paralysis. The consumption of large quantities of *Lathyrus* grain containing high concentrations of the glutamate analogue neurotoxin β-oxalyl-L-α, β-diaminopropionic acid (ODAP, also known as β-*N*-oxalyl-amino-L-alanine, or (BOAA) causes paralysis, characterized by lack of strength in or inability to move the lower limbs. A unique symptom of lathyrism is the atrophy of gluteal muscles (buttocks). ODAP is a poison of mitochondria leading to excess cell death, especially in motor neurons. Lathyrogens caused two diseases: Neurolathyrism: found in human and Osteolathyrism: found in animal

2.8 Phytates

Phytate (is also known as Inositol hexakisphosphate (InsP6)) is the salt form of phytic acid, are found in plants, animals and soil.Inositols with 4, 5 or 6 phosphate groups are common in the seed of many of our grain legume and can reach concentration higher than 10% of dry matter. In monocotyledons such as wheat and rice, phytates is present in germ of corn and in the aleurone or bran layer allowing an easy separation by milling. However, in diacotyledons seeds such as legumes, nuts and oilseeds, phytates are found closely associated with proteins and is often isolated or concentrated with protein fraction of these foods. They can be regarded as stores for phosphate and mineral nutrients that are important for plant nutrition and especially vulnerable during germination (Jansman *et al*., 1998) [17]. Since, phytates contains complex zinc, iron,magnesium and calcium ions in the digestive tract, they can cause mineral ions deficiency in animals and human. Again, these compounds seem to serve a double response i.e. defence and phosphate and mineral store. Phytate contain of food can be lowered by addition of enzymes which hydrolyze them.

2.9 Oxalates

Oxalates cannot be seen tasted or smelled. Yet we consume them almost every day. Since oxalates prove harmless for the majority of the population. Oxalates are chemical compounds that are found naturally in our bodies, as well as in many plants, fruits, and essentially all nuts and seeds. When oxalates meet up with damaged tissues, they bind with calcium and crystallize causing irritation and pain to the tissues. In turn, this either causes or increases inflammation. It can be particularly painful when the crystals implant themselves in areas where they prevent other material from passing through (such as in your digestive tract). Additionally, in the case of an permeable, or "leaky" gut, a lot of oxalates are absorbed into body and this overload is linked to several health issues including fibromyalgia, autism, kidney stones, vulvodynia and hypothyroidism, just to name a few Oxalic acid and its salts, particularly calcium oxalate, can have deleterious on human nutrition and health, particularly by decreasing calcium absorption and aiding the formation of kidney stones (Noonan and Savage, 1999) [19]. Along with oxalates produced by human metabolism, dietary oxalate is excreted in the urine, but not all oxalates are soluble, and high levels of urinary oxalate can lead to crystallization and stone formation. Soluble oxalate in the diet can bind calcium from other sources in the diet and from the body (Noonan and Savage, 1999) [19]. About 85% of all kidney stones contain calcium salts, calcium oxalate and or calcium phosphate. Spinach (Spinacia oleraceae) is a well-known high-oxalate vegetable; it belongs to the family Chenopodiaceae. Another well-known high-oxalate food in this family is sugar beet (Beta vulgaris). Many vegetables from the family Amaranthaceae are high in oxalate content. "Amaranth" is used as a general term for all members of the plant genus Amaranthus (family Amaranthaceae). The leaves and seeds of Amaranthus species are edible. Both Amaranthus and Amaranthus tricolor are high in oxalate content. Recent reports showed that Amaranthus can reduce calcium absorption in rice-based diets due to its high oxalate content. For urolithiasis and osteoporosis patients, intake of such foods should be restricted. Sweet potato belongs to the family Convolvulaceae; its root is used as a common staple food in and its leaves as a vegetable. The leaf used to have a bitter taste, but after years of breeding improvement it is now a popular dish on the dinner table. The oxalate content of sweet potato leaf was found to be 48.6 mg/100 g. beside oxalate stone formation, high oxalate intake has other effects on human beings. Small doses of oxalate in the body may cause headaches, pain and twitching in muscles, and cramps. Larger doses can cause a weak and irregular heartbeat, a drop in blood pressure, and signs of heart failure. Large doses of oxalate can rapidly put a person in a shock-like state, causing convulsions, coma, and possibly death. The mean lethal dose for an adult is about 15 to 30 g, but the lowest reported lethal dose is only 5 g (or about 70 mg/kg). A delayed effect of oxalate ingestion is kidney damage, which can lead to renal failure due to deposition of calcium oxalate crystals.

Table 2: Oxalate content of raw vegetables

Raw Vegetable	Oxalate content milligrams per 100 gram serving
Spinach	750
Beet greens	610
Okra	146
Parsley	100
Leeks	89
Collard greens	74

Source: United State Department of Agricultural, Human Nutrition information services

2.10 Nitrate ($NO_3^{-)}$ and Nitrite (No_2^{-})

Nitrogen is essential to the nutrition and function of plants, so plants exert a close metabolic control on the concentration of nitrate and other nitrogen compounds. Nitrate is mainly to be found in cell vacuoles and is transported in the xylem. The xylem carries water and nutrients from the roots to the leaves, whereas the phloem carries the products of photosynthesis from the leaves to the growth points of the plant. This affects the distribution of nitrate between the leaves and storage organs such as seeds or tubers. This means that leaf crops such as cabbage, lettuce and spinach have fairly large nitrate concentrations whereas storage organs such as potato tubers, carrots, leeks, onions, seeds and pods of pea and bean plants have relatively small concentrations. Another consequence of the transport system is that young leaves have lower nitrate concentration than older leaves. Such a relation was shown for cabbage with greatest nitrate concentrations in the outer leaves and much smaller nitrate concentration in the innermost leaves (Greenwood and Hunt, 1986) [16]. Both environmental and agricultural factors can influence the nitrate concentrations in vegetables. The former include soil moisture, light intensity and temperature and the latter fertilizers, variety and crop protection strategies.

Nitrate accumulation can have serious deleterious effect. Within the gastrointestinal tract nitrate is reduced to nitrite which is absorbed into the blood stream where it binds with haemoglobin oxidizing ferrous iron to ferric iron to from methaemoglobin. This form of haemoglobin complex is incapable of oxygen transport. The result is Anoxia, specifically referred to as methaemoglobinaemia.

Table 3: Nitrates level and effect in human body

Level in %	Effect
0.5-2%	Methemoglobin in their blood
10%	Skin and lips can take on bluish tinge (cynosis)
25%	Weakness and rapid pulse
50-60%	Person can lose consciousness

Source: Argonne National Lboratory, Auust 2005

2.11 Goitrogens

Goitrogens are naturally-occurring substances that can interfere with function of the thyroid gland. Goitrogens get their name from the term "goiter," which means an enlargement of the thyroid gland. If the thyroid gland is having difficulty making thyroid hormone, it may enlarge as a way of trying to compensate for this inadequate hormone production. "Goitrogens," like circumstances that cause goiter, cause difficulty for the thyroid in making its hormone. There are two general categories of foods that have been associated with disrupted thyroid hormone production in humans: soybean-related foods and cruciferous vegetables.

Soybean-related foods - Included in the category of soybean-related foods are soybeans themselves as well as soy extracts, and foods made from soy, including tofu and tempeh. While soy foods share many common ingredients, it is the isoflavones in soy that have been associated with decreased thyroid hormone output. Isoflavones are naturally-occurring substances that belong to the flavonoid family of nutrients. Flavonoids, found in virtually all plants, are pigments that give plants their amazing array of colors. Most research studies in the health sciences have focused on the beneficial properties of flavonoids, and these naturally-occurring phytonutrients have repeatedly been shown to be highly health-supportive. The link between is of lavones and decreased thyroid function is, in fact, one of the few areas in which flavonoid intake has called into question as problematic. I so flavones like genistein appear to reduce thyroid hormone output by blocking activity of an enzyme called thyroid peroxidase. This enzyme is responsible for adding iodine onto the thyroid hormones.

Cruciferous vegetables - A second category of foods associated with disrupted thyroid hormone production is the cruciferous food family. Foods belonging to this family are called “crucifers," and include broccoli, cauliflower, Brussels sprouts, cabbage, mustard, rutabagas, kohlrabi, and turnips. Isothiocyanates are the category of substances in crucifers that have been associated with decreased thyroid function. Like the is of lavones, isothiocyanates appear to reduce thyroid function by blocking thyroid peroxidase, and also by disrupting messages that are sent across the membranes of thyroid cells.

Goitrogens interfere with iodine utilization. They may block the transporters responsible for moving iodine into the cell (e.g., the NIS) or they may interfere with the manufacturing process for the thyroid hormones (e.g., T_3 and T_4). Sometimes, they interfere with thyroid peroxidase (TPO) activity. TPO is important in the process of attaching iodine to the tyrosine for the production of T_4 and T_3. Other substances can block the deiodinization of the thyroid hormones or can block the receptor sites for the thyroid hormones. Another possible way goiter may be caused in low iodine areas is by eating large amounts of soy components or other substances which increase fecal bulk. This causes excessive excretion of T_4, which the thyroid has difficulty in compensating for because of the inadequate iodine stores. Although research studies are limited in this area, cooking does appear to help inactivate the goitrogenic compounds found in food. Both isoflavones (found in soy foods) and isothiocyanates (found in cruciferous vegetables) appear to be heat-sensitive, and cooking appears to lower the availability of these substances. In the case of isothiocyanates in cruciferous vegetables like broccoli, as much as one third of this goitrogenic substance may be deactivated when broccoli is boiled in water.

2.12 Anti-vitamins
An antivitamin is simply 'a substance that makes a vitamin ineffective'. A vitamin antagonist is essentially the same thing as an antivitamin. It is a substance that lessens or negates the chemical action of a vitamin in the body**.** Anti-vitamin factors raw kidney beans contain anti-vitamin E that produces necrosis of liver and muscular dystrophy. Antivitamin B_1 is found in bracker fern. Antivitamin E has also been noted in isolated soya protein, which is suspected to betocopherol oxidase. Linseed contains an anti-pyridoxine factor that depresses growth. The factor responsible is L-amino acids, D-proline that occurs as peptide linatine in combination with glutamic acid. L-amino-D-proline is about 4 times as active as linatine (Saluanke, 2006) [27].

Table 4: Antinutritional compounds/toxicants of vegetables

Sl. No.	Vegetable	Toxic compound	Adverse effect
1	carrot	Carota-toxin	Neurotoxic symtoms
2	lettuce	Nitrates, alkaloids	methemglobinaemia
3.	Brassica vegetables	Glucosinolates, choline-esterase inhibitor, s-methyl cystiene sulfoxides	Goiter,digestive disorder
4.	Beet, spinach	Oxalates, nitrates, phytate, saponins, nitrosamine	Methemglobinaemia reduse bioavailability of certain minrel such as Ca, Fe & Zn. carcinogenic
5.	Sweet potato	Ipomeamarone	Enzyme inhibitor
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, compound having anti-vitamin properties.	allergens
9.	Asparagus	Saponins, Chaline-esterase inhibitor	Neurotoxic
10.	Solanaceous vegetables	Alkaloids	Birth defect,protease inhibitors
11.	Potato	Solanine and Chaconine	Invertase inhibitor
12.	Tomato	tomatine	Gastric discomfort
13.	Parsley,celery	Psoralens, Terpenoid, Alkaloids, Choline-esterase inhibitor	dermatitis
11.	Potato	Solanine and Chaconine	Invertase inhibitor
12.	Tomato	tomatine	Gastric discomfort
13.	Parsley,celery	Psoralens, Terpenoid, Alkaloids, Choline-esterase inhibitor	dermatitis
14	Pungent pepper	capsaicin	Skin irritaton gastric -discomfort

Source: Chatto *et al*., (2011) [7]

3. Reduction methods of Antinutrient
Method of reduction of Antinutrient usually natural toxins will only be harmful if consume them in large quantities over a long period of time but you can help to reduce the amount you eat by doing the following things:

3.1 Advice to trade
- Store potatoes in a cool, dry and dark environment. Avoid keeping stocks for prolonged periods.
- Display a smaller stock at any one time.
- Discard stocks that show signs of sprouting, greening, physical damage or rotting.
- Do not use sprouting, greened or damaged potatoes for making food products.

3.2 Advice to public
- Avoid buying potatoes that show signs of sprouting, greening, physical damage or rotting.
- Buy foods from reputable sources and do not patron illegal hawkers.
- Do not eat vegetables and fruits raw or undercooked if they are usually consumed cooked.

3.3 Storage
- Remove potatoes from plastic bags and place them in a cool, dry, and dark place at home.
- Store only small amounts of potatoes at home.
- Discard potatoes that show signs of sprouting, greening, physical damage or rotting.

3.4 Cyanogenic plants
- Cutting the cyanogenic plants into smaller pieces and cook thoroughly in boiling water to release toxic hydrogen cyanide before consumption helps reduce the level of the toxin. Since hydrogen cyanide is volatile, it is easily removed by open-lid cooking.
- When the cooking method chosen is heating under dry-heat or at low moisture contents, limit the intake of the cyanogenic plants to only small amounts.

3.5 For other vegetable
- Cook beans such as green beans, red kidney beans and white kidney beans, cassavas, bamboo shoots thoroughly at boiling temperature after thorough soaking in clean water.
- Do not use raw or inadequately-cooked green beans or other bean species in the preparation of salad dishes. Always bear in mind a few raw beans can cause food poisoning symptoms.
- Store potatoes in a dark, cool and dry place and avoid eating potatoes that show signs of greening, sprouting or rotting.
- Limit the intake of the ginkgo seeds to not more than a few seeds per day and avoid eating uncooked seeds, especially for children.
- Take a balanced and varied diet containing plenty of fruits and vegetables as they are nutritious and safe to eat after observing the above risk avoidance or reduction measures.

4. Conclusion
Antinutritional factors can be present in vegetables that are normally nutritious and good for health when ingesting certain amount. The amount of ingestion of vegetable

containing phytochemicals which cause food poisoning depends on the several factors like cooking method and individual susceptibility. The level of toxins in vegetable crops vary according to geographical environment and species differences. The vegetables are safely ingested when appropriate measures are taken like careful selection, enhanced public awareness and careful post-harvest processing of these vegetables before consumption. The consumption of fresh vegetables reduces the potential risk of more dangerous health problems such as cancer, heart disease, obesity and diabetes. The need for exploration of anti-nutritional information in vegetables is significant in overcoming nutritive disorders in order to contribute to health and nutritional security in India.

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