Review Article

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A SYSTEMATIC REVIEW OF NATURAL TOXINS IN FOOD PLANTS

D. Saravanan [1], D. Thirumalai [2], A. Sivakumar [3], I. V. Asharani [3]*

[1]Department of Pharmaceutical Chemistry, Ratnam Institute of Pharmacy, Pidathapolur, Nellore, Andhra Pradesh, India

[2]Department of Chemistry, Thiruvalluvar University, Serkkadu, Vellore, Tamil Nadu, India

[3]Chemistry Division, School of Advanced Sciences, VIT University, Vellore, Tamil Nadu, India

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***Corresponding author**

E-mail: ivasharani@gmail.com

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ABSTRACT

Natural toxins are present in numerous types of plants and most of these plants are normally ingested as food. These types of compounds whenever consumed in large quantity or when they are not cooked properly may lead to food poisoning. Plant toxins are found naturally in vegetables and fruits which have been the common food sources. They are generally metabolites produced through plants to protect themselves against different threats like predators, insects, bacteria and fungi. Natural toxins can also be found in food plants because of natural choice as well as new reproduction methods which enhance these defensive mechanisms. Different kinds of natural toxins can be present in various parts of a plant. The parts of the harvest plant that are utilized for a food sources include the roots, tubers, stems, fruits, buds and foliage. The aim of the review is to provide the toxicological summary of a few of the toxins found in ingested food.

Keywords: Harmful toxins; Food; Plants; side effects

INTRODUCTION

Plants have a wide range of pharmacologically effective phytochemicals. Many of these have been discovered to be really helpful for the treatment of a variety of human as well as animal diseases (e.g. colchicines, atropine, and digitoxin); although few plant phytochemicals produce harmful effects after exposure. The onset of harmful effects could be really immediate or take a little time to develop. Fortunately, among thousands of plants present in the environment, relatively few of the plants only cause acute and life-threatening diseases when ingested. The variety of chemical components in the plants is really amazing and in most of the cases, still the function a specific phytochemical substance, i.e. the normal ecology of the plant remains unknown. The inclusion of toxic phytochemical substances in the plants is considered to confer some extent of defence against plant potential predators like ruminants and insects. There are some broad categories of toxicological plant phytochemicals such as terpenes, phenolic and tannins, alkaloids, peptides, proteins, amino acids, glycosides, acids and essential oils[1]. Within each broad classification, there is remarkable chemical heterogeneity.

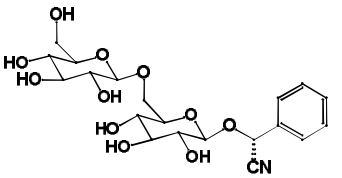
A numerous factor is playing a role in a human or animal to be poisoned through plants. Basically, there is the need that the sensitive types of animal ingest or generally be exposed to, a poisonous plant in a suitable time of year. There are several examples of species variations in regard to sensitivity into the toxic effects of the plants. Further, it is possible for the animals to adapt the potentially toxic plant when exposure is permitted to occur during a period. For example, ruminants, who ingest oxalate containing plants like *Halogeton glomeratus* can tolerate to certain levels that are fatal to other non-adapted animals[2].Consumption of potentially poisonous plant is the main route of poisoning in humans or animals. It is very important to emphasize that numerous, but not all, poisonous plants are not really palatable. So, if given the choice, humans or animals can avoid the consumption of these plants, although they are present in the environment widely. Timing of the consumption could be important since the concentrations of harmful toxins in the plants can differ from season to season and throughout the growing season for the plant[3].

The medical diagnosis of plant poisonings is very challenging since the ingestion of several plants produces non specific clinical signs that could not be distinguished from other disease conditions. Additionally, death caused by toxic plant ingestion frequently does not result in characteristic post-mortem lesions, due to relatively limited numbers of tests are available to identify the plant toxic compounds in post mortem or ante-mortem samples. In many instances, the simplest way to help the diagnosis of the plant poisoning is to confirm the existence of the poisonous plant in the environment, ensure that the plant was ingested and correlate clinical findings, if it is possible, with those known to be associated with the suspect plant[4].The aim of the review is to provide the toxicological summary of a few of the toxins found in common ingested food.

TOXINS IN FOOD PLANTS

Amygdalin

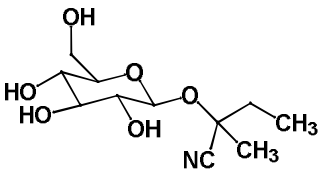
The seeds of apple, apricot, plum, bitter almond and peach contain small amount of a poisonous cyanogenic glycosides, called amygdalin. Amygdalin derived from aromatic amino acid phenylalanine. It is hydrolysed by β-glucosidase and amygdalase to afford L-mandelonitrile and gentiobiose. Mandelonitrile is further hydrolysed to hydrogen cyanide and benzaldehyde. Hydrogen cyanide causes cyanide poisoning. The quantities of amygdalin present in the seeds not enough to be dangerous to human health, but consumption of more quantity of seeds may lead to a fatal dose[5].



Amygdalin

Lotaustralin

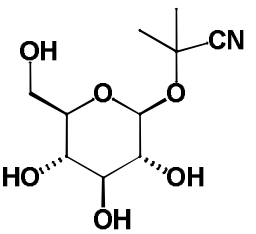
Lotaustralin is a cyanogenic glycoside found in austral trefoil, cassava, lima bean, and roseroot. It is the glycoside of methyl ethyl ketone cyanohydrins[6]. Lotaustralin hydrolysed by the enzyme linamarase to form glucose and toxic compound hydrogen cyanide. Hydrogen cyanide causes a drop in blood pressure, rapid respiration, rapid pulse, headache, dizziness, mental confusion, vomiting, stomach pains, diarrhea, stupor, convulsion followed by terminal coma.



Lotaustralin

Linamarin

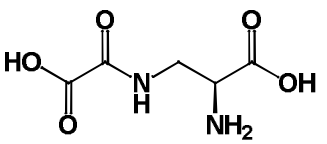
Linamarin is another cyanogenic glycoside present in the leaves and roots of lima beans, cassava and flax. It is decomposed by gut flora in the human intestine to form hydrogen cyanide[7]. Consumption of food prepared from insufficiently processed plant material containing linamarin to produce dietary toxicity, called konzo diseases. Dietary exposure to linamarin was also been reported as a risk factor in developing diabetes and glucose intolerance[8,9].



Linamarin

Oxalyldiaminopropionic acid (ODAP)

This is a structural analogue for the neurotransmitter glutamate found in the grass pea and Indian pea. It is the neurotoxic amino acid responsible for motor neuron degeneration syndrome, neurolathyrism, characterized by pyramidal tract neurons in the area of cortex controlling legs and in the spinal card. As a result, lower body paralysis[10,11].



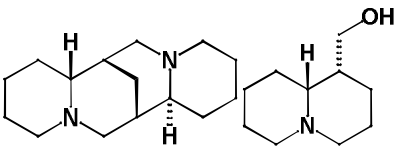
Oxalyldiaminopropionic acid

Phytohaemagglutinin

It is a lectin found in high concentration in uncooked red and white kidney beans and in low concentration in green, broad and common beans. Phytohaemagglutinin has complex oligosaccharide containing mannose, galactose and N-acetylglucosamine. It is causing severe stomach ache, diarrhea, and vomiting in humans when consumed as raw or half-boiled. Phytohaemagglutinin was destroying the epithelia of the GI tract that causes local haemorrhage, interfere with cell mitosis, and damage the liver, kidney, and heart. The beans also contain an alpha amylase inhibitor, which affects the digestion of starch[12,13].

Lupinine and sparteine

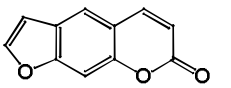
These are quinolizidine alkaloids present Lupines seeds. Bitter lupines contain more amounts of lupinine and sparteine than sweet lupines. Both quinolizidine alkaloids are unsuitable for human and animal ingestions[14].



Sparteine Lupinine

Psoralen

It is present in all citrus fruits. Psoralen structurally related to coumarin, which is toxic to cats, dogs and some animals. It causes symptoms like photosensitivity, depression, vomiting, and diarrhea[15].

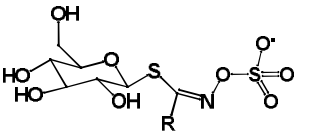

Psoralen

Prussic acid

Prussic acid also called as hydrogen cyanide. It is cyanogenic glycosides found in the leaves of apple, cherry, oak mass and peach pits. Prussic acid is hydrolysed by β-glucosidase, and emulsion enzymes to hydrogen cyanide from glycoside. Hydrogen cyanide stop the cells utilizing oxygen, as a result cells necrosis and tissue damage. Clinical symptoms of prussic acid poisoning were rapid breathing, incoordination and cardiac arrest in certain cases[16].

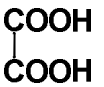
Glucosinolates (Goitrogens)

Glucosinolates are derived from glucose and amino acid. It is present in cassava, spinach, soybeans, pears, sweet potatoes, peanuts, strawberries, peaches, broccoli, cabbage, cauliflower, canola, Brussels sprouts, mustard greens, rapeseed and radishes. Glucosinolates are sulphur containing substances which are metabolized by the enzyme thioglucosidase to produce nitriles, sulphur, isothiocyanates, and thiocyanate. The isothiocyanates undergo cyclisation to produce goitrins which increasing the goitrogenic activity. It is suppressing the uptake of iodine that causes the thyroid gland to enlarge, forming a goiter. Upon consumption, they give pungent taste due to breakdown of glucosinolates[17].



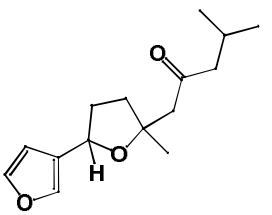
Glucosinolates

Oxalic acid
Oxalic acid present in spinach, rhubarb, purslane and in parsley. It can bind with calcium and minerals, making them insoluble and thus reducing the bioavailability. Consumption of foods containing oxalates could cause kidney stones, decreased bone growth, renal toxicity, diarrhea, vomiting, convulsions, and coma[18].



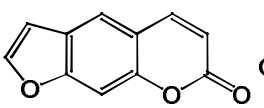
Oxalic acid

Ipomeamarone
Ipomeamarone is found in kumara, which is a member of the sweet-potato family. It can produce harmful toxins due to insect attack, injury and some other stress. Ipomeamarone makes the kumara to taste bitter. The toxin concentrations are normally highest in the area of the damage. Make sure that the destroyed parts in kumara are removed before cooking[19].

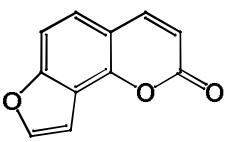


Ipomeamarone

Furocoumarins
Parsnips generally consist of a variety of natural toxins referred as furocoumarins such as psoralen and angelicin. They are most likely produced during the defending of the plant with regards to happens to be pressured. The amount for the furocoumarins is generally highest during the peel or at damaged areas of the plant[20]. Furocoumarins could cause stomach pain and may produce a painful skin reaction if exposed to sun UV rays[15,21,22]. It is very important to peel the plant prior to cooking in order to eliminate all the damaged parts.

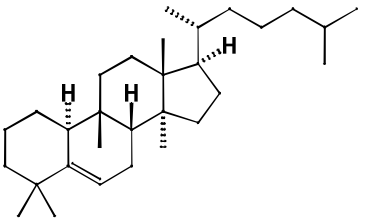


Psoralen



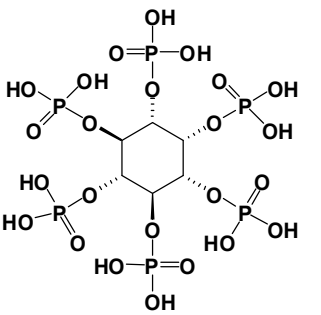
Angelicin

Cucurbitacins (courgette)
Zucchini could commonly consist of a group of naturally occurring toxins generally cucurbitacins. These types of toxic substances give zucchini plant a bitter taste. Intake of zucchini has poses people to experience stomach cramps, vomiting, and diarrhea[23].



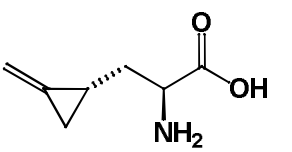
Cucurbitacins

Phytic acid
Phytic acid, also called as phytate. It is present in the germ and bran of several plant seeds, grains, nuts and legumes. Phytic acid is a simple sugar that contains six phosphate side chains. It is a dietary source of phosphorus and a good chelator of divalent cations like copper, zinc, iron, calcium and magnesium[24]. Investigations suggest that phytate-mineral complexes were insoluble in the intestinal tract and thus reducing mineral bioavailability and also inhibit the digestive enzymes like pepsin, trypsin, β-glucosidase and α-amylase[18]. So, intake of foods containing high concentrations of phytic acid could decrease the starch and protein digestibility.



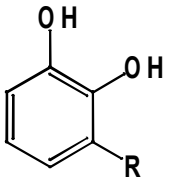
Phytic acid

Hypoglycin
Ackee is the national fruit of Jamaica and found in Central America, Caribbean nations, southern Florida, and South America. Ingestion of ackee fruit produce Jamaican vomiting sickness syndrome due to the presence of alkaloids hypoglycin A and B. The concentration of hypoglycin A and B in the ripe fruit is undetectable. It inactivates the various flavoprotein acyl-CoA dehydrogenases, causing disturbances of the oxidation of amino acids and fatty acids. This can lead to inhibition of gluconeogenesis that can precipitate a dangerous decrease in blood glucose level which can be lethal. Clinical signs of hypoglycin poisoning include vomiting, convulsions, coma and finally death that occur within 6 to 48 hours after consumption[25,26].



Hypoglycin A

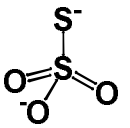
Urushiol
Mango sap, stems, leaves and peel have urushiol, which is an allergen that may cause urushiol-induced contact dermatitis in sensitive people[27].



U rushiol

Thiosulphate

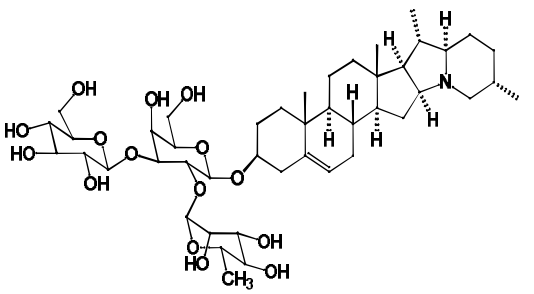
Onions and garlic have thiosulphate. It is harmful to horses, cats, dogs and many types of animals. Thiosulphate damage the red blood cells, haemolytic anemia by the formation of Heinz bodies in erythrocytes of horses, cats, dogs and many other animals[28,29].



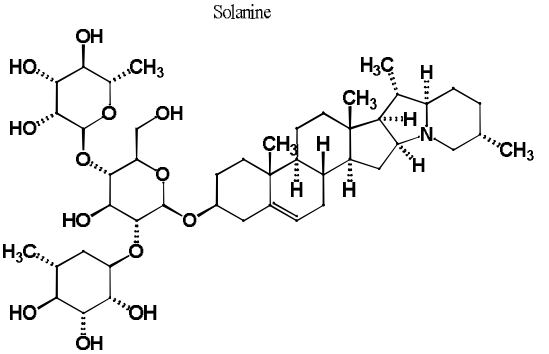
Thiosulphate

Solanine and chaconine

Potatoes have poisonous glycoalkaloids such as solanine and chaconine. Solanine is also present in hyoscyamus and atropa. Glycoalkaloids are produced within the parenchyma cells for the periderm as well as the cortex of the tubers. It produces armed effects in animals and insects and help to defend from predators. The glycoalkaloids found in all potato tubers are not reduced by cooking and washing. The level of solanine and chaconine in potatoes is enough to produce harmful effects in human beings. The glycoalkaloids affects the nervous system, leading to extreme digestive disturbances, diarrhea, headaches, weakness, cramps, confusion, and in severe cases coma and death[30,31].



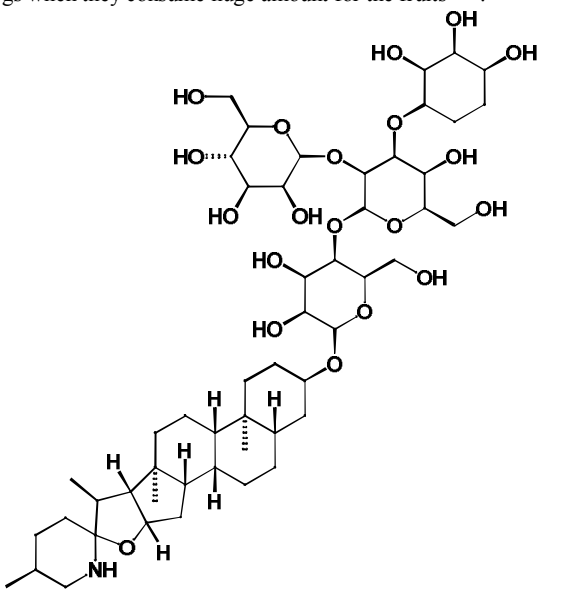
Solanine



Chaconine

Tomatine

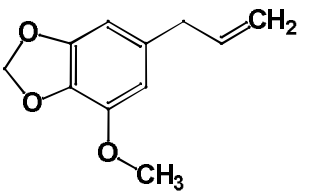
Leaves, stems and green unripe fruit of tomato contain steroidal alkaloid tomatine. It's containing two molecules of D-glucose and one molecule of each of D-xylose and D-galactose. When consumed, tomatine lead to nervous excitement and digestive upset. The usage of tomato leaves for herbal tea has-been responsible certain death. Mature tomatoes don't have any detectable quantity of tomatine. Tomato plants are harmful to dogs when they consume huge amount for the fruits[32,33].



Tomatine

Myristicin

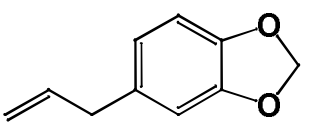
Myristicin is naturally occurring acaracide and insecticide, present in mace and nutmeg. It is also found in carrot, black pepper, dill and celery parsley. It is structurally related to mescaline and a weak inhibitor of monoamine oxidase. Myristicin produce unpleasant symptoms like anxiety, tachycardia, nausea, fear, and tremor. It also produces toxicological symptoms in humans, which are similar to alcohol intoxication[34].



Myristicin

Safrole

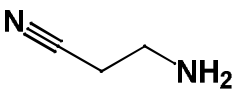
1-allyl-3,4-methylenedioxybenzene (safrole)is present in aromatic oils of cinnamon, nutmeg, and camphor and is the main constituent of oil of sassafras. It produces testicular atrophy, weight loss, malignant liver tumors and bone marrow depletion. The mechanism of carcinogenicity is assumed to involve cytochrome P-450 catalysed hydroxylation of safrole to 1-hydroxy safrole which upon subsequent metabolism produces extremely reactive electrophiles that bound to DNA[35].



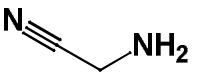
1-allyl-3,4-methylenedioxybenzene

Lathyrogens

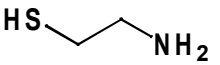
Lathyrogens such as β-aminopropionitrile (BAPN), aminoacetonitrile (AAN) and aminoethanethiol present in legumes like vetch and chick peas. They are the analogues of amino acids and can act as antagonists of glutamic acid. Glutamic acid is a neurotransmitter present in the brain. When lathyrogens are consumed in huge amount by a human being, they produce a crippling paralysis of the lower limbs and could lead to death[36].



3-Aminopropanenitrile



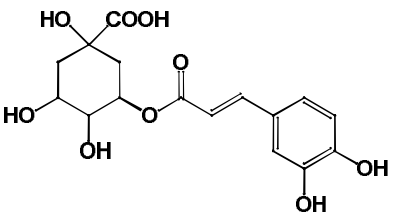
Aminoacetonitrile



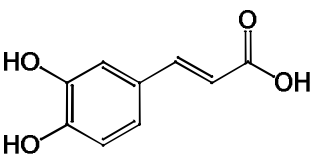
2-am inoethanethiol

Anti-thiamin compounds

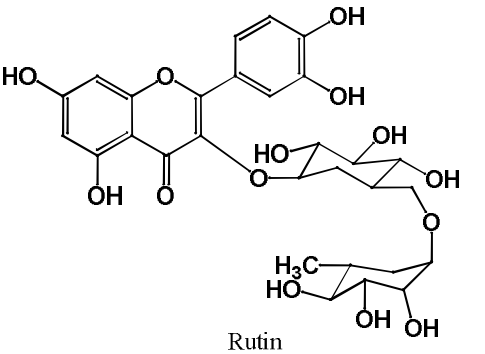
Anti-thiamin compounds such as chlorogenic acid, caffeic acid and tannins found in beets, mung beans, Brussels sprouts, rice bran, some berries and buckwheat seeds. Some of the bioflavonoids like rutin and quercetin in-actives the thiamin. Vitamin B_1involved in energy production through the metabolism of carbohydrates, which is important for the normal working of heart, muscles and nervous system. Lack of thiamine produces a disease referred to as beriberi. Signs include poor arm and leg coordination, weakness, muscle pain, loss of appetite, nervous tingling throughout the body and irritability[24].



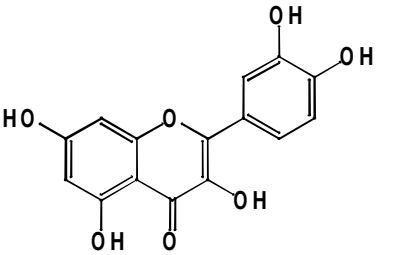
Chlorogenic acid



Caffeic acid



Rutin



Q uercetin

CONCLUSION

Natural toxins can be present in edible plants that are normally nutritious and good for health when ingesting certain amount. The amount of ingestion of food plants containing phytochemicals which cause food poisoning depends on the several factors like cooking methods and individual susceptibility. The level of toxins in the food plants vary according to geographical environment and species differences. The food plants are safely ingested when appropriate measures are taken like careful selection, sufficient processing plus cooking and limitation of intake. The consumption of fresh vegetables and fruits reduces the potential risk of more dangerous health problems such as cancer, heart disease, obesity and diabetes. The people are advised to be cautious in the amount of intake and are recommended to observe the effects after ingestion, particularly for elderly people and children.

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