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## Plant toxins-useful and harmful effects

Chandra Sekhar J, Sandhya S\*, Vinod KR, David Banji, Sudhakar K, Chaitanya RSNACK

Department of Pharmacognosy, Nalanda College of Pharmacy, Cherlapally, Nalgonda, Andhra Pradesh, India-508001.

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### Abstract

**Plan:** To review the useful and harmful effects of plant toxins.

**Prologue:** Poisonous chemicals found in plants are normal biochemicals. They have been developed as an evolutionary response for self-protection. Therefore, plants are deliberately poisonous and their toxicity to humans and other animals is an example of natural selection. The surviving plants, therefore, have not been subjected to selective pressures which might influence them to produce toxins. The alkaloids are by far the most predominant of plant toxins and because of their enormous structural diversity and various modes of action, examples may be chosen from among them to serve as paradigms for virtually every type of plant-herbivore interaction.

**Outcome:** Since plant toxins show many useful effects they can be used in treating respective diseases. They can be modified to show better affinity and efficacy. Regardless of the structure of a particular toxin, it is likely to have evolved and been elaborated biosynthetically under pressure from a specific predator or limited group of predators. Commercial crops for human food usage must therefore have optimal concentration of biologically active natural products, low enough to be nontoxic to the consumer (at least when eaten in reasonable quantities) but sufficiently great to repel or limit pests.

**Key words:** Toxins, secondary metabolites, alkaloids, herbivore, adverse effect

### Introduction

Plant toxins are substances produced as secondary metabolites that are identical to extra cellular bacterial toxins in their properties. They show both useful and harmful effects in human beings and animals. They Show a wide range of side effects from minor itching, nausea, vomiting to adverse effects like psychosis, paralysis, teratogenicity, arrhythmias. They are useful in production of cosmetics, ulcers, menstrual cramping, cancer and in treatment of man ailments and diseases. Toxins may enter into the by body either by inhalation, swallowing or by contact. The action is based on their chemical constituents which are classified into alkaloids, glycosides, proteins, oxalates, anti vitamins, tannins, volatile ether layers etc. They act by altering specific mechanisms involving enzymes, receptors and even genetic material at particular cells and tissues. Poisonous plants have a seed, root, leaf, stalk, fruit or juice where even a relatively small amount, taken either internally or externally, can lead to injury to the human body. In some species the poisonous constituents occur throughout the whole plant. In others they are concentrated in one or more parts.



For correspondence: [sanpharm@gmail.com](mailto:sanpharm@gmail.com),

Contact: +91 9010055004

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The degree of toxicity also depends on the location (including height above sea level), climatic factors including the local microclimate (light, warmth, humidity), the growing season, type of soil, fertilization, plant variety and age. The condition of the poisonous plant material is equally important (dried, chewed, cooked, as tea). The dose of course is the most important factor.

Plants contain a variety of toxic compounds commonly called "secondary compounds" that affect the behavior and productivity of wild and domestic animals. There are many classes of these toxic compounds; however soluble phenolics, alkaloids, and terpenoids are the most common. Soluble phenolics include flavonoids, isoflavonoids, and hydrolysable and condensed tannins. There are a huge variety of plant poisons and it is difficult to organize the myriad plant toxins in an understandable manner. Plant toxins are described according to the organ system in the human body which they affect, e.g. cardiotoxins, neurotoxins etc. The difference between the terms 'medicinal' and 'poisonous' is sometimes smaller than one might think<sup>1-3</sup>.

### Classification

Plant toxins are classified based on their structural and chemical properties. They are grouped into alkaloids , glycosides , tannins , proteins , oxalates , enzyme inhibitors , antivitamins , phytoestrogens , volatile etheric layers , photo sensitizing substances<sup>1,4,5</sup>.

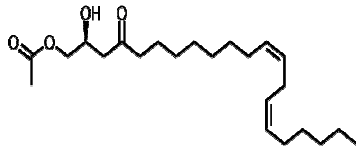
- Alkaloids include indole alkaloids, pyrrolizidine alkaloids, tropane alkaloids, opium alkaloids, vicine and convicine alkaloids.
- Glycosidal toxins include cardiac glycosides, goitrogenic glycosides, anthraquinone glycosides, mustard oil glycosides, saponin glycosides, cyanogenetic glycosides.
- Tannins like pyrogallol.
- Proteins like lectin, abrin, ricin, cicutoxin, anisatin, gelonin, falcarinol, oenothatoxin etc. Antivitamins like thiaminases , Phytoestrogens like coumestrol . Volatile etheric layers such as ushuriol, Photo sensitizing substances including hypericin .
- Enzyme inhibitors like Cholinesterase inhibitors, Protease inhibitors, Amylase inhibitors. Others include Lathrogens, Anti-thiamin compounds, Avidin.

### Plant toxins<sup>6-9</sup>

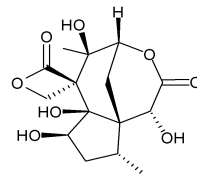
- *Abrin, Anisatin, Andromedotoxin, Apocyanin, Amygdalin, Aesculin, Anabasine, Anagyrene, Asparagine , Avidin*
- *Brucine*
- *Chaconine, Cicutoxin, Cicutiol, Cardinilides, Cycasin, Cyanarin, Confoline, Convolmine, Convicine, Convoline, Convosine, caratotoxin, cucurbitacin*
- *Delphinine, Djenkolic acid, Dhurrin, Levo-Duboisine*
- *Epipodophyllotoxin*
- *Falcarinol, Frascin, Fagopyrin quinines , furocoumarin*
- *Gelonin, Gossypol, Grayanotoxin, Gallotoxin*
- *Hymexon, Hypericin, Hymenoxon, Hyoscine*

- *Illicin, Isoalyl thiocyanates, ipomeamarone*
- *linamarin, lotaustralin, Lycorine, Laetrile, Lectin, Lantanene*
- *beta-methylamino-l-alanine, Macrozamin, Mezeiin, 4-methoxypyridoxine*
- *Nitrates, Naudicoline, Nerosides*
- *Oenanthotoxin*
- *Phytotoxin, Pseudaconitine, Pyrrolizidine Alkaloid, Persin, Prunassin, Podopyllotoxin, Phenanthridineprolamine, Phytolaccine, Phytolaccatoxin, Phytolaccigenin, Protoanemonin*
- *Resiniferatoxin, Ricin, Ranunculin*
- *Saponin, Scopolamine, Solamargine, Solasodamine, Solasodine, Solasonine, Solauricidine, Solauricine, Strychnine, Swainsonine, Syringomycin, Sambunigrin, Solanine, Shankhpushpin*
- *Thionins, Tinyatoxin, Tutin, Tremetol, Taxine*
- *Ushuriol*
- *Vicine*

## 2.2 Structures of few plant toxins



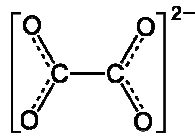
*Persin*



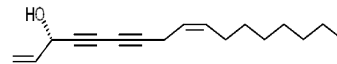
*Anisatin*



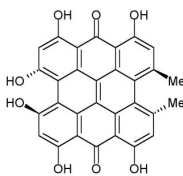
*Cicutoxin*



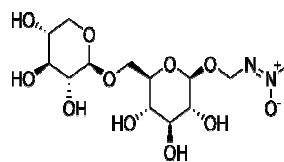
*Oxalate*



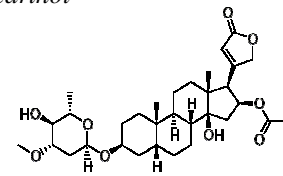
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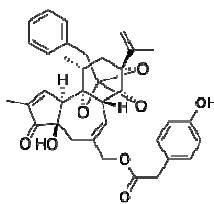
*Oleandrin*



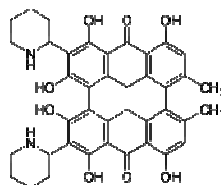
*Hypericin*



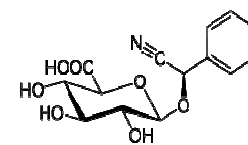
*Macrozamin*



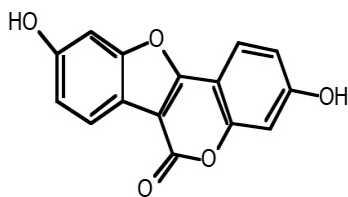
*Tinyatoxin*



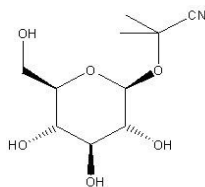
*Fagopyrin*



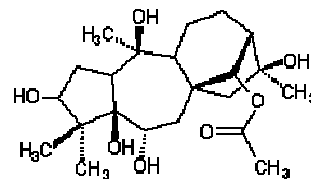
*Laetrile*



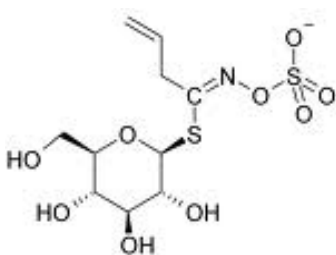
*Coumestrol*



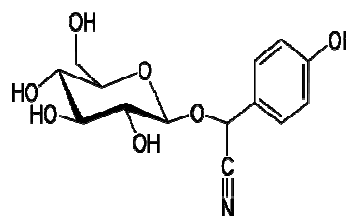
*Linamarin*



*Andromedotoxin*



*Sinigrin*



*dhurrin*

Plant toxins act on all parts of the body with some common symptoms like vomiting, nausea. They show actions based on the way of exposure and concentration. They are both useful and harmful.

## Conclusion

A plant grows in a highly competitive environment. It is continually threatened by other plants encroaching upon the space from which it draws its sustenance, by micro-organisms, by insects, and by both large and small mammalian, avian, or reptilian herbivores.

In order to survive, each plant must draw upon a complex of defenses, which may be physical, such as spines or leathery leaves, or chemical. These compounds are of most interest because they are often specific to a particular species or genera and must, therefore, have been designed to serve a particular protective function. Among the most prevalent are numerous classes of phenolics, terpenes and steroids, cyanogenic compounds, and alkaloids.

Table 1: Mechanism of action of different toxins

S.no	Chemical constituents	Mechanism of action
1	<b>Alkaloids<sup>10-14</sup></b>	
	Glycoalkaloids	Interacts with mitochondrial membranes. opens the potassium channels of mitochondria, increasing their membrane potential. Increase concentration of Ca <sup>2+</sup> in the cell that triggers cell damage and apoptosis.
	Indole alkaloids	Beta carbolines act as MAOinhibitors.link to benzodiazepine receptors. Increase serotonin action.
	Pyrazolidine alkaloids	Cross link with dsDNA. Anti-mitotic action. Form fibrous tissue.
2	<b>Cyanogenic glycosides</b>	Release HCN. Inhibit oxidative process of cells.
	Saponin glycosides	Interact with LC cells. Tcell mediated contact dermatitis.
	Goitrogenic glycosides	Inhibition of both Thyroid peroxidase (TPO) Lactoperoxidase (LPO). Inhibits both TPO-catalyzed iodination and coupling.
	Anthraquinone glycosides	Produce myoelectric alterations in intestinal smooth muscle and induce accumulation of lipid. Mucosal injury
	Mustard oil glycosides	Aqueous extracts of mustard also inhibited formation of diene, triene, and tetraene conjugates in human erythrocyte membranes. carcinogen activation is associated with down regulation of the cytochrome P-450 enzyme system.
3	<b>Oxalates</b>	Form salts with "+"charged ions. Form Ca <sup>++</sup> oxalate, ferric oxalate. Form stones in kidney.
4	<b>Tannins</b>	Precipitate proteins.
5	<b>Proteins</b>	
	Abrin	Inhibit protein synthesis.
	Anisatin	Suppress GABA induced currents. Show use dependency.
	Cicutoxin	Cholinergic poisonGABA antagonist disrupts CNS.
	Thionins	Attacks membrane, make it permeable, decrease sugar uptake,K <sup>+</sup> loss.
	Gelonin	Exert N glycosidase action on 28 r RNA of ribosome. Cleave at A 4324.
	Epi podophyllotoxin	Inhibit topoisomerase II.
6	<b>Antivitamins</b>	Coumestrol -- Inhibit aromatase, hydroxy steroid dehydrogenase.Phytoestrogens exert their effects primarily through binding to estrogen receptors ,alpha (ER- $\alpha$ ) and beta (ER- $\beta$ ) and many phytoestrogens display somewhat higher affinity for ER- $\beta$ compared to ER- $\alpha$ . Phytoestrogens may also modulate the concentration of endogenous estrogens by binding or inactivating some enzymes.
	Thiaminases	Aids carbohydrate metabolism for CNS muscles, heart.
	Hypericin	Nonspecific kinase inhibitor inhibits dopamine beta dehydrogenase, increase dopamine.
7	<b>Volatile Etheric Layers</b>	
	Ushuriol	T-cell mediated dermatitis, changes shape of integral membrane proteins.
8	<b>Enzyme inhibitors</b>	
	Cholinesterase inhibitors	Cholinesterase inhibitors ultimately modify cholinergic signaling through disruption of acetylcholine degradation.
	Protease inhibitors	The protease inhibitors can slow virus production. Non-toxic reversible metallo-protease inhibitor. Inhibits many membrane-bound peptidases which are critical regulators of peptide hormones.
	Amylase inhibitors	Inhibiting membrane-bound alpha-glucosidases.

Table 2: Pharmacological actions<sup>15-18</sup>

Body system	Pharmacological use	Plant
Nervous system	Provide strength to nerves	(Bind weed) <i>Convolvula arvensis</i>
	Used to treat anxiety	(Poppy) <i>Papaver somniferum</i>
	Treat depression as herbal medicine	(St Johns weed) <i>Hypericum perforatum</i>
	Used to treat insomnia	(Bind weed) <i>Convolvula arvensis</i>
	Used as brain tonic	
	Tranquilizer, antidepressant	<i>Hypericum perforatum</i>
Cardiovascular system	Tone cardiac muscles	Apricot, Bind weed <i>Convolvula arvensis</i>
	Effects include weak pulse	
Digestive system	Used for ulcers	Apricot
	Treat tonsillitis	Poke weed
	Used as laxative	Rhubarb, Black walnut
Respiratory system	Treat bronchitis	Jack in pulpit
	Treat asthma	Poppy
	Tone respiratory system	Apricot, Horse radish, Poppy
Reproductive system	Treat menstrual cramping	Bane berry
Urinary system	Treat infections	Bindweed ( <i>Convolvula arvensis</i> )
	Diuretic system	Bind weed, Horse radish
Circulatory system & tissues	Treat cancer	Apricot, Yew, Abrus
	Decrease bad cholesterol	Apricot
	Astringent & anti-inflammatory	Black walnut
	Relive pain	Bleeding heart
	Blood purifier	Black walnut
Integumentary System	Treat leprosy	Black walnut

Table 3: Harmful effects of plant toxins

S.no	Body system	Harmful effects	Plant
2	Nervous System	Cause convulsions	<i>Black henbane, Death onion, Hemlock, Golden chain tree Cocklebur, English laurel, Yew</i>
		Depression	<i>Castor bran, Crostalaria, Horse tail, Night shade</i>
		Nervousness	<i>Chokecherry, Yew, Johnson grass, Wild cherry</i>
		Coma and death	<i>Night shade, Golden chain tree, Death onion</i>
		Arrythmia	<i>Dogbane, Foxglove, Lily of the valley, Rhododendron, Monks hood</i>
		Tachycardia	<i>Angels wing, Elderberry, Squaw wood, Thown apple, Desert bailiya</i>
	Cardiovascular System	Bradycardia	<i>False hellebore, Yew, Night shade, Narcissus</i>
		Fluid accumulates around hears: Shock & death:	<i>Avocado</i>
		Hypovolemic - Cold extremities - Cardiac arrest -	<i>Castor bean (Ricinus communis) Oleander (Nerium oleander) Bane berry Night shade</i>
3	Digestive system	Diarrhoea, vomiting	<i>Avocado, Castor, Fox glove, Lily of the valley, Golden chain</i>
		Colic pain	<i>Oleander, Oats, Black locust</i>
		Equine colic	<i>Avocado</i>
		Bloat Ataxia	<i>Monks hood, Peg weed, Castor, Black henbane</i>
		Abdomen pain paralysed tongue.	<i>Wild mustard, White snake root, Potato, Philodendron, Dogbane, Flix weed</i>
		Some cause Constipation –	<i>Black locust</i>
		Apetite loss –	<i>Desert bailiya, Laburnum</i>
		GIT cancer –	<i>Eagle fern</i>
		Many increase salivation -	<i>Cow bane, Wildcherry, Rosary pea, Bitter cup Thornapple</i>
		Some decrease salivation –	
4	Respiratory system	Pneumonia	<i>Sneeze weed, English laurel, Desert bailiya, Rhododendron</i>
		Respiratory paralysis	<i>Worm seed, Larkspur, Hemlock, Poppy, Tobacco</i>
5	Reproductory system	Abortion	<i>Johnson grass, Worm seed</i>
		Teratogenic Cramps, Foetal mummification	<i>Lupine, Thornapple, Rhododendron, Skunkcabbage, Tobacco English laurel</i>
6	Muscular system	Recumbancy	<i>Cockle bar, Carvey Lead, English laurel, Laburnum</i>
		Tremor/weakness	<i>Angel wing, Hemlock, Desert bailiya, Buck eye, Night shade</i>
7	Urinary system	Haematurea	<i>Eagle fern</i>
		Liver necrosis	<i>Scotch broom</i>
		Liver degeneration	<i>Squaw wood</i>
8	Circulatory system. & tissues	Thrombocytopenia	<i>Eagle fern, Red maple</i>
		Methemoglobinaemia	<i>Worm seed</i>
		Bone marrow depression	<i>May apple</i>
		Anaemia	<i>Nettle, Red maple</i>
9	Integumentory System	Photosensitivity	<i>Buckwheat, Flixweed, Crostalaria</i>
		Sloughing / corneal ulcer	<i>Buck wheat</i>
		Corneal ulcer	<i>Burdock</i>
		Mydriasis	<i>Angels wing, Hemlock</i>
		Conjunctivitis	<i>Poinsettia</i>
		<i>Poison Oak</i>	

Table 4 Examples of plant toxins

S.no	Common name	Botanical name	Plant part	Chemical constituents	Pharmacological action
1	Andromeda	<i>Andromeda floribunda</i>	Whole plant	Andromedotoxin	*Paralysis,Death
2	Apricot	<i>Prunus Americana</i>	Wilted leaves	Cyanogenic glycosides,laetrile	+Cancer,Ulcers,Detoxification, Constipation,Decrease LDL
3	Avocado	<i>Persea spp.</i>	Leaves	Persin	*Equinecolic,Resp.Distress.Fluid Accumulate around heart
4	Azalea	<i>Rhododendron indica</i>	Whole plant	Glycosides	*Constipation,Decrease LDL
5	Baneberry	<i>Actea rubra</i>	Whole plant	Cardiogenic toxins,beta-sitosterol glycoside	+Menstrual Cramping *Cardiac Arrest,Death
6	Bind weed	<i>Convolvula arvensis</i>	Whole plant	Shankhapushpin,convolimine,conoline,convosine,confoline	+braintonic,insomnia,diuretic, Strength to nerves, Urinary infections, Tone heart muscles, Hair growth
7	Bitter weed/sneeze weed	<i>Helenium.spp.</i>	Whole plant	Glycosides,sesquiterpene lactones	*Muscle Tremor,Dehydration, Cough,Pneumonia
8	Black henbane	<i>Hyocyanus niger</i>	Whole plant	Tropine alkaloids-atropine	*Bloat,Ataxia,IntestinalStasis, Excitement,Convulsions,Mydriasis
9	Black locust	<i>Robinia pseudocadia</i>	Bark,seeds	Glycoprotein-abrin,ricin,lectin	*Colicic pain, Constipation, Diarrhea,Muscle Weak ness,Ataxia
10	Black walnut	<i>Jugulans nigra</i>	Whole plant	-----	+Anti Inflammatory,Astringent,Blood Purifier,Laxative,Vermifuge, Ganarene,Leprosy
11	Bleeding heart	<i>Dicentra exemia</i>	Whole plant	Alkaloids	+Sharp pains like tooth pain
12	Bouncing bet	<i>Saponaria officinalis</i>	Whole plant	Saponins	*Hepatopathy,GIT Disturbances
13	Brackenfern	<i>Petridium aquilinum</i>	Whole plant	Thiaminase	*GIT Cancer,Enzoitic Haematuria,Thrombocytopaenia,Depression, Blindness, Decreased Platelets
14	Buck wheat	<i>Fagopyrum esculentum</i>	plant except ripe seeds	Fagopyrin,dianthroquinones	*Photosensitization,Sloughing of skin <sup>24</sup>
15	Buffalo burr	<i>Solanum rostratum</i>	Whole plant	Solanine,atropine alkaloids	*Bloating,Diarrhoea
16	Burdock	<i>Atrium spp.</i>	Spiny burs	-----	*Corneal ulcer,Trauma
17	Buttercup	<i>Ranunculus .spp</i>	Whole plant	Oily glycoside,ranunculln	Increased salivation *,Reddening of mucous membrane
18	Angels wing	<i>Caladium .spp</i>	Whole plant	Tropane alkaloids	*Constipation,Resp Failure,Mydriasis,Muscle Weakness,Tachycardia
19	Callalily	<i>Zantedesctea</i>	Whole plant	Oxalates	*Kidney stones
20	Castorbean	<i>Ricinus communus</i>	Seeds	Ricin,lectin	*Diarrhea,Pyrexia,Depression, Anorexia,Bloat, Hypovolemic Shock <sup>21</sup>

-: Harmful effects;    + : Useful effects;    ---- : not reported



Plant toxins-useful and harmful effects

21	Choke cherry	<i>Prunus virginiana</i>	Wilted leaves	Cyanogenic glycoside-prunassin, amygdalin	*Increased salivation, Nervousness, Decreased O <sub>2</sub> in body.
22	Christmas rose	<i>Helleborus niger</i>	Whole plant	Protoanemonin	-----
23	Clematis	<i>Clematis spp.</i>	Whole plant	Oily glycoside, ranunculin	*Increased salivation,
24	Cockle bur	<i>Xanthium spp.</i>	Burs	Carboxyactryctyloside, sulfated glycosides	*Abdominal Pain, Depression, Ataxia, Recumbency, Convulsions, Renal nephrosis
25	Cow cockle	<i>Saponaria spp.</i>	seeds	Saponins	*Diarrhea, Liver failure
26	Crocus	<i>Colchicum spp.</i>	Whole plant	Alkaloid-colchicine	-----
27	Crotolaria	<i>Colchicum spp.</i>	Whole plant	Pyrrazolidine alkaloids	*Weight loss, Depression, Head pressing, Haemoglobinurea, Photosensitization
28	Dock fourvy leaf	<i>Rumex crispus</i>	Whole plant	Soluble oxalates	*Muscle Tremor, Tetany, Weakness, Kidney failure, Depression, Recumbency, Hypocalcemia
29	Daphne	<i>Daphnemezerium</i>	Whole plant	Diterpenoid-mezerein	-----
30	Death onion	<i>Zigadenus spp.</i>	Whole plant	Steroidal alkaloids	*Increased salivation, Vomiting, Tremor, Ataxia, Prostration, Convulsions, Coma
31	Desert bailiya	<i>Elaeagnus multiradiata</i>	Whole plant	Hymenoxon, sesquiterpene lactones	*Apetiteloos, Tremor, Incoordination, Prostration, Pneumonia, Cough, Tachycardia
32	Dumb cane	<i>Duffenbachia spp.</i>	Whole plant	Oxalates	*Tremor, Ataxia, Knuckling Of Joints, Recumbency, Increase in serum K <sup>+</sup> Levels
33	Indian hemp/dogbae	<i>Apocynum cannabinum</i>	Whole plant	Cardiac glycosides-cyanarin, apocyanin	*Abdominal pain, Haemorrhagic Gastritis, Arrythmias, Decrease in heart rate
34	Dutchmans braa-hae	<i>Dicentra cucullaria</i>	Whole plant	Alkaloids	*Teratogenicity, Hypotension, Shock
35	Elder berry/dane wort	<i>Sambucus spp.</i>	Foliage	Cyanogenic glycosides, samburin	*Tachycardia, Panting, Asphyxiation, Abortions
36	Elephant ear	<i>Colocasia spp.</i>	Whole plant	Oxalates	* Tremor, Ataxia, Knuckling Of Joints, Recumbency, Increase in serum K <sup>+</sup> Levels
37	English ivy	<i>Hedra helix</i>	Whole plant	Glycosides	-----
38	Falsehellebore	<i>Veratrum woodii</i>	Whole plant	50 alkaloids	*Teratogenicity, Hypotension, shock
39	Fescue	<i>Festuca arundinacea</i>	Whole plant	Endophyte fungus	*Teratogenic, Carcinogenic, Hepatocarcinomas
40	Flix weed	<i>Linum spp.</i>	Whole plant	Cyanide	*Tongue paralysis, Weight loss, Photosensitivity, Blindness Hepatopathy
41	Fox glove	<i>Digitalis purpurea</i>	Whole plant	Cardiac glycosides	*Arrythmias, Diarrhea, Irregular Pulse, Tachycardia
42	Hemlock	<i>Conium maculatum</i>	Whole plant	Alkaloids, conine	*Tremors, Incoordination, Weak pulse, Resp. Paralysis, Convulsions, Abortion,
43	Holly	<i>Ilex spp.</i>	Berries	Illicin	-----
44	Horse chest nut/buckeye	<i>Aesculus spp.</i>	Whole plant	Glycosides, aesculin, frasin	*Muscle twitch, Weakness, Proteinurea, Glucosurea
45	Horse tail	<i>Equisetum spp.</i>	Whole plant	Thiaminase	*Diarrhoea, Weight Loss, Muscle Degeneration, Depression
45	Horse radish	<i>Aimoracea rusticana</i>	Roots	glycocinolates	+Diuretic, Bronchitis, Sinus congestion, UTI, Ingrowing toe nails
47	Hyacinth	<i>Hyacinthus spp.</i>	Whole plant	Alkaloids	*Teratogenicity, Hypotension, Shock
48	Hydrangea	<i>Hydrangea spp.</i>	Whole plant	Cyanogenic glycosides	+Cancer, Ulcers, Detoxification, *Constipation, Decrease LDL
49	Jack in pulpit	<i>Arisaema triphyllum</i>	Whole plant	Oxalic acid, asparagine	+Rheumatism, Bronchitis
50	Jerusalem cherry	<i>Physalis spp.</i>	Whole plant	Alkaloids	*Teratogenicity, Hypotension, Shock <sup>25</sup>

-: Harmful effects; + : Useful effects; ---: not reported

51	Thorn apple	<i>Datura stramonium</i>	Whole plant	Alkaloids,hyocyanine	*Drymuzzle,Bloat,Apetitelos, Teratogenic,Mydriasis Hallucinogen
52	Johnson grass	<i>Sticrgum halapense</i>	Whole plant	Cyanogenic glycosides,dhurrin	*Nervousness,Abortion, Teratogenic,Increased Salivation,Incontinence
53	Kansas thistle	<i>Solanum rostratum</i>	-----	Solanin	* Salivation, Trembling, Progressive Weakness and Paralysis
54	Golden chain tree	<i>Laburnum anagyroides</i>	Whole plant	Quinazolidine alk.aloids	*Apetite Loss,Vomiting,Diarrhea,Irregular Gait,Coma,Convulsions,Mydriasis, Recumbency
55	Lanbquarterwort seed	<i>Chenopodium</i>	Seeds	Oxalates,sulfates	*Respiratry Failure,Abortion,Methemoglobinemia
56	Lantana	<i>Lanaya camara</i>	Whole plant	Triterpene acids, lantanene A,B	*Haemorrhagiodiarrhea,Constipation,Conjunctivitis,Bilestasi s,Jaundice, Photosensitivity
57	Lark spur	<i>Delphinium tricornne</i>	Whole plant	Diterpene alk.aloids,methyl aconitine,nudicaulie	*Bloat,Respiratory paralysis,Muscle Paralysis
58	English laurel	<i>Prunus laurocerasus</i>	Wilted leaves, stems	Diterpene compounds,grayanotoxins	*Anorexia,Arrythmias,Bradycardia,
59	Lily of the valley	<i>Convollaria majalis</i>	Whole plant	38 cardinolides	*Vomiting,Diarrhea,Arrythmias
60	Lobelia	<i>Lobelia</i>	Whole plant	Pyridine alk.aloids	-----
61	Lupine	<i>Lupinus spp.</i>	Whole plant	Quinazolidine alk.aloids,anaggrine	*Teratogenic,Lupinosis,Respiratory failure
62	Maple	<i>Acer rubrum</i>	Leaves	Podophyllotoxin	*Diarrhoea,Abdominal pain,Liver Degeneration,Bone marrow dysfunction
63	Milk weed	<i>Asclepius spp.</i>	Whole plant	Cardenolides	*Vomiting,Diarrhea,Arrythmias
64	Mole plant	<i>Euphorbia lathyris</i>	Whole plant	Diterpene esters	-----
65	Monks hood	<i>Aconitum spp.</i>	Whole plant	Mono basio diterpene alk.aloids	*Muscle paralysis,Staggering Gait,Arrythmias,Bloat , Increased respiratory rate
66	Mountain laurel	<i>Kalmia latifolia</i>	Whole plant	Andromedotoxin	*Paralysis,Death
67	Narcissus	<i>Narcissus spp.</i>	Whole plant	Phenanthridene alk.aloids,lycorine	*Hypotension
68	Nettle	<i>Urtica dioica</i>	Whole plant	-----	*Arthritis,Anemia,Hay Fever,Anti Itching,Benign Prostate Hyperplasia
69	Night shade	<i>Solanum spp.</i>	Whole plant	Steroidal alk.aloids	*Diarrhea,Tremor,Shock,Coma,Kidnefailure, Mydriasis,Depression
70	Oats	<i>Avena sativus</i>	Whole plant	Prolamines	*Coleic diseases
71	Oleander	<i>Nerium oleander</i>	Wilted leaves	Oleandrin,nereoside	*Colic Pain,Arrythmias,Weak Pulse,Mydriasis,Blindness,Shock <sup>24</sup>
72	Peach	<i>Prunus persica</i>	Whole plant	Cyanides	*Increased Saliva,Nervousness
73	Pennycress	<i>Thalspi</i>	Whole plant	Isoallyl thiocyanites	-----
74	Pepper grass	<i>Lepidium</i>	Whole plant	Isoallyl thiocyanites	-----
75	Philodendron	<i>Philodendron</i>	Whole plant	Oxalates	*Dysphagia,Stomatitis,Dermatitis,Edema
76	Pig weed	<i>Amaranthus retroflexus</i>	Whole plant	Oxalates,nitrates	*Tremor,Ataxia,Knuckling Of Joints,
77	Poinsettia	<i>Euphorbia retroflexus</i>	Whole plant	Steroidalsaponins, diterpenoid euphorbial esters	*Conjunctivitis,Mucous irritation
78	Poison ivy	<i>Rhus radicans</i>	Whole plant	Urushiol (oil)	*Reddening,Swelling,Blisters on skin,Lung Damage
79	Poison oak	<i>Toxicodendron pubescens</i>	Sap	Urushiol	*Dermatitis
80	Poke weed	<i>Phytolacca Americana</i>	Whole plant	Phytolaccatoxin,phytolaccine, phytolaccigenin	*Convulsions,Seizures,Purging,Prostration, Fetching,Tremor,Dyspnea +Arthritis,Tonsillitis
81	Poppy	<i>Papaver somniferum</i>	Whole plant	Alk.aloids-morphine,codeine	*Sedation,Respiratory Distress,Abdominal Cramps
82	Potato	<i>Solanum tuberosum</i>	Foliage	Glycol alk.aloids-solanine	*Diarrhea,Abdominal Cramps,Head ache
83	Privet	<i>Ligustrum spp.</i>	Berries	Glycosides	*Diarrhea,Abdominal Cramps,Head ache
84	Rag wort	<i>Senecio spp.</i>	Whole plant	Pyrrrolizidone alk.aloids	-----
85	Redoak	<i>Quercus rubra</i>	Leaves,shoots	Gallotoxins	*Pneumonia, Teratogenic,Arrythmias,Bradycardia, Coma

-: Harmful effects;      + Useful effects;      --: not reported

86	Rhododendrn	<i>Rhododendron</i>	Whole plant	Grayanotoxins	*Anorexia,Arrythmias,Bradycardia,Pneumonia,Teratogenic,Paralysis,Coma
87	Rhubarb	<i>Rheum raponticum</i>	Whole plant	Oxalic acid	*Nephrotoxic, Corrosive+Laxative, Cathartic
88	Rosary pea	<i>Abrus precatorius</i>	Whole plant	Abrin	*Photosensitivity,vomiting,convulsive seizures,pulmonary edema,
89	Sago palm	<i>Cycas revoluta</i>	Whole plant	Glycosides,amino acid BMAA	*Diarrhea,Abdominal Cramps,Head ache
90	Scotch broom	<i>Cytisus scoparius</i>	Whole plant	Saponins	*diarrhoea,liver necrosis,wt.loss
91	Skunk cabbage	<i>Symplocarpus foetida</i>	Whole plant	Complex alkaloids	*Teratogenic,Shock,Bradycardia
92	Smart weed	<i>Polygonum spp.</i>	Whole plant	Nitrates	*Tremor,Ataxia,Knuckling Of Joints,Recumbency,Increase in serum K+ Levels 19
93	Sneeze weed	<i>Helenium</i>	Whole plant	Sesquiterpene lactones	-----
94	Snow on mountain	<i>Euphorbia marginata</i>	Whole plant	Diterpene esters	*diarrhoea, increased saliva
95	Stjohns wort	<i>Hypericum perforatum</i>	Whole plant	Hypericin	*Photosensitivity,sloughs on skin+antidepressant(herbal medicine)
96	Sweet pea	<i>Lathyrus spp.</i>	Whole plant	Glycosides	*Diarrhea,Abdominal Cramps,Head ache
97	Tobacco	<i>Nicotiana tobacum</i>	Whole plant	Nicotine,anabasine	*diarrhea,teratogenic,CVS,RESP.paralysis
98	Tomato	<i>Lycopersicon esculentum</i>	Foliage	Glyco-alkaloids	*Diarrhea,Abdominal Cramps,Head ache
99	Vetch	<i>Vicia spp.</i>	Seeds	Cyanide	* Increased Saliva,Nervousness
100	Cow banewater hemlock	<i>Cicuta spp.</i>	Whole plant	Cicutoxin,cicutiol	*teeth grinding, increased saliva,convulsions,resp.paralysis,mydriasis <sup>22,23</sup>
101	White snake root	<i>Eupatorium rugosum</i>	Whole plant	Ketones,tremetol	*Difficulty in shewing,Swallowing,
102	Wild carrot	<i>Daucus carota</i>	Leaves	Falcarinol	*Lathyrism,Contact dermatitis
103	Wild cherry	<i>Prunus serotina</i>	Leaves,twigs, seeds	Cyanide	*Increased Saliva,Nervousness
104	Wild mustard	<i>Brassica spp.</i>	Whole plant	Isoallyl thiocyanites	*Blindness,Wt.Loss,Tongue Paralysis,Hepatotoxic,Photosensitivity
105	Yellow jasmine	<i>Gelsemium spp.</i>	Whole plant	-----	* Difficulty In Breathing,Death,Tremors,Convulsions,Weakness
106	Yew	<i>Taxus spp.</i>	Whole plant	Cardiotoxin	+Cancer *Severe gastroenteritis,Convulsions, Shock, Coma and death
107	Sago palm	<i>Zamia integrifolia</i>	Whole plant	Glycosides,cycasin, macrozamin	*Staggering Gait,Proprioception,Incoordination,Anorexia, Increased Thirst

- : Harmful effects; + : Useful effects; ---: not reported

Insect attack upon a plant may cause it to mobilize its defensive toxins in such a way that they are concentrated at the most threatened site, whether it be leaf tissue, flower, root, or seed. The generally small size of insects ensures that sufficient metabolite can be produced to kill, injure, or deter the attacker. The cost to the plant of producing its chemical weapons in the arms-race against its rapidly evolving insect enemies is extremely high. Valuable resources of water, nutrients, and energy must be utilized in the frequently complex biosynthetic route to an effective toxin. It is obviously advantageous to the plant if it can survive by producing either a minimal amount of a compound which is especially toxic to its particular predator or is localized at the point of attack.

Commercial crops for human food usage must therefore have optimal concentration of biologically active natural products, low enough to be nontoxic to the consumer (at least when eaten in reasonable quantities) but sufficiently great to repel or limit pests. Similar considerations must be applied to the production of feed and forage for livestock. Concentration and location of the toxin are the primary considerations in evaluating the toxicity of poisonous plants.

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