

POISONOUS PLANTS

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(A) Poisonous principles

- A variety of compounds produced in or absorbed by plants may cause toxic reactions when ingested by animals. Commonly recognized natural toxic principles include the following:

A. Alkaloids

B. Polypeptides

C. Amines

D. Glycosides (glucosides)

i). Cyanogenetic (nitrile) glycosides

ii). Goitrogenic substances

iii). Irritant oils

iv). Coumarin glycosides

v). Steroid and triterpenoid glycosides

vi). Cardiac glycosides

vii). Saponins

E. Oxalates

F. Resins or resinoids

G. Phytotoxins (Toxalbumins)

H. Mineral poisonings... (Copper, lead, cadmium, fluorine, manganese)

I. Nitrogen

i). Nitrites-nitrates

ii). Nitrosos

ii). Gaseous oxides of nitrogen

J. Selenium

K. Molybdenum

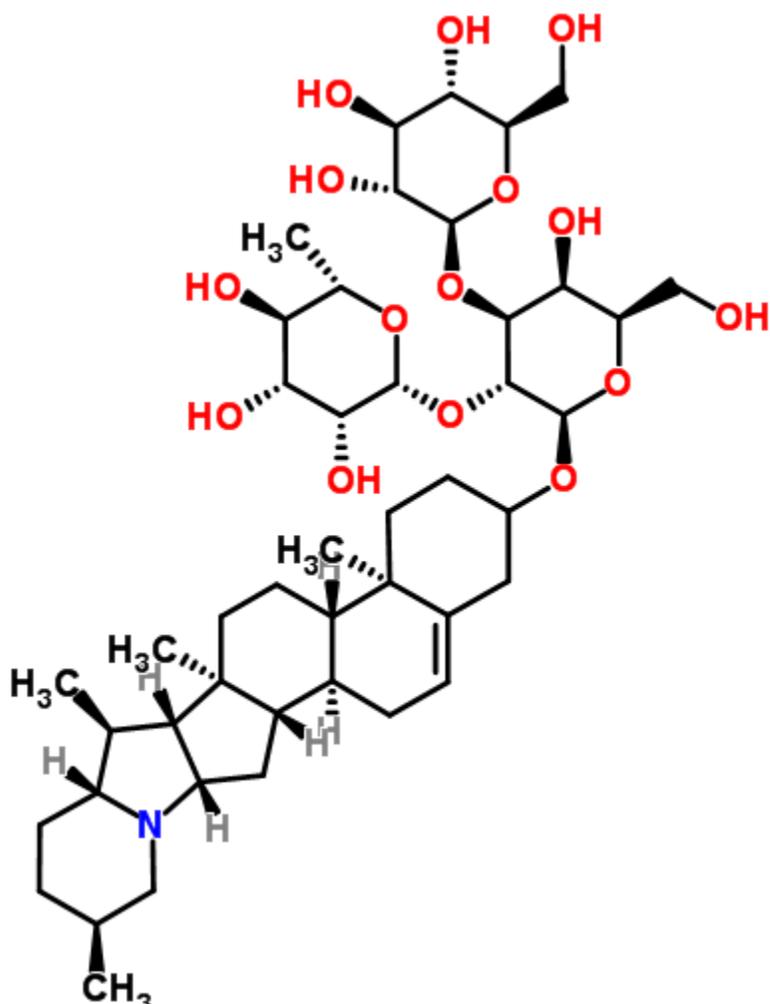
L. Compounds causing photosensitivity

i). Primary photosensitization

ii). Hepatogenic photosensitization

M. Fungicidal toxin: Persin

- A number of species of plants contain a toxic substance unique to each e.g. hydroquinone in xanthium species.
- Some syndromes, which are associated with particular plants, may turn out to be the result of absence of a necessary factor in the diet rather than presence of a toxic one. E.g. thiaminase in *Pteridium aquilinum* (*Bracken fern*).
- A Large and miscellaneous group of plants contain toxic principles which produce injury in an entirely mechanical fashion.
- A few plants contain two or more toxic principles which are not in the same chemical group e.g. a liver toxin and potentially toxic nitrate levels in *Tribulus terrestris*
- In many cases, the chemical definitions of the toxic principles are not on parallel grounds, and characteristics which identify a given moiety as a member of one may not exclude its concurrent membership in another. One of the best examples of this is the toxic principle solanine found in species of *Solanum* (nightshades, etc.).
- It is a glycoside because of the presence in it of a sugar residue (solanose).



- It is considered among the alkaloids because on hydrolysis it yields the alkaline solanidine which fits the definition of an alkaloid and is physiologically active.
- Solanidine bears chemical relationship to the basic structure of sterols, so that solanine may be considered to belong to the steroid glycosides.
- Finally, its physical characteristics are those of a saponin.
- Not all compounds mentioned are toxic. Some alkaloids, for example, produce no significant physiological reaction. Therefore, chemical detection of one or another of these classes of compounds in a particular plant neither establishes the toxicity of that plant nor, if the plant is known to be toxic on other evidence, does it serve necessarily to identify the source of toxicity.

(B). Specific plant poisoning

Alkaloids

- Alkaloids (alkali-like) are those products of chemical analysis of plants which are not true bases (alkalis) but share certain chemical similarities with them.
- They are basic in reaction and form salts with acids.
- Generally insoluble in water but extractable in organic solvents, they occur as crystalline solids (a few as liquids) in pure form, and in plants they are most often found as soluble organic acid-alkaloid salt.
- They are almost universally bitter in taste.
- Alkaloids are particularly common in some plant families e.g. *Leguminosae*, *Amaryllidaceae*
- Alkaloids of similar structure are commonly found in closely related plants. Occasionally, the same alkaloid may be detected in species of no immediate relationship e.g. nicotine in: *Nicotiana* (tobacco); *Lycopodium* (Princess pine) and *Equisetum* (horsetail).
- Most alkaloids produce a strong to very strong physiological reaction when introduced into an animal; a few produce no reaction.
- In most cases, activity is effected primarily via the nervous system. Lesions are absent.
- Some types of alkaloids, however, produce completely different syndromes e.g. Pyrrolizidine alkaloids cause severe liver damage.
- Classically, alkaloids are identified by color reactions in spot tests with certain reagents. Chromatography and electrophoresis are useful techniques in their separation and identification.
- Alkaloid content of a plant usually varies little with ecological factors such as nature of the growing season, climate and availability of water.
- When present in a plant, alkaloids are frequently distributed throughout its structures. Any part may be dangerous to livestock.

Types of alkaloids and poisonous plants which contain them.

Type of alkaloid	Plant genus	Examples
Tropane	<i>Atropa</i>	Deadly night shade
	<i>Datura</i>	Jimson weed
	<i>Hyocyamus</i>	henbane
Pyrrolizidine	<i>Crotolaria</i>	Rattlebox, crotolaria
	<i>Echium</i>	Vipers bugloss
	<i>Heliotropium</i>	Heliotrope
	<i>Senecio</i>	Groundsel, senecio
Pyridine	<i>Conium</i>	Hemlock, poison hemlock
	<i>Lobelia</i>	Indian tobacco
	<i>Nicotiana</i>	tobacco
Isoquinoline	<i>Argemone</i>	Prickly poppy
	<i>Chlidonium</i>	Celandine poppy
	<i>Corydalis</i>	Fitweed
	<i>Dicentra</i>	Dutchmans breeches
	<i>Papaver</i>	Poppy
	<i>Sanguinaria</i>	bloodroot
Indole	<i>Claviceps</i>	Ergot
	<i>Gelsemium</i>	Caroline Jessamine
	<i>Hippomane</i>	Manchineel

	<i>Peganum</i>	African rue
Quinolizidine	<i>Baptisia</i> <i>Cytisus</i> <i>Laburnum</i> <i>Lupinus</i> <i>Sophora</i>	False indigo Scotch broom Goldenchain, laburnum Lupine, bluebonnet Mescalbean, frijolito
Steroid alkaloids (a). Solanum type (solanidine)	<i>Lycopersicon</i> <i>Solanum</i>	Tomato Potato, nightshades
(b). Veratrum type (veratramine)	<i>Amianthium</i> <i>Veratrum</i> <i>Zigadenus</i>	Staggergrass False hellebore Death camas
Polycyclic Diterpenes (delphinine)	<i>Aconitum</i> <i>Delphinium</i>	Monkshood larkspur

**(b). Poisonous plants containing uncharacterized or incompletely characterized alkaloids
(Excluding algae and fungi)**

Genus	Example
<i>Allium</i>	onion
<i>Buxus</i>	box
<i>Ervatamia</i>	Crape jasmine
<i>Festuca</i>	fescue
<i>Fritillaria</i>	fritillaria
<i>Gloriosa</i>	Glory lily

<i>Ornithogalum</i>	Star of bethlehem
<i>Taxus</i>	yew

- The poisonous principle of *Astragalus* has been stated to be of alkaloidal nature. Some members of this genus are selenium accumulators. Others are responsible for the nervous disease of horses, sheep and cattle called, “loco”.

Polypeptides and amines

- Certain algae e.g. *Microcystis*, a blue green algae, fungi e.g. Amanita, a mushroom, and higher plants e.g. *Blighia sapida*, akee, contain toxic peptides.
- *Phoradendron flavescens* contain amines (Phenylethylamine, tyramine) which are credited with toxic action.
- Ergot (*Claviceps*) alkaloids are accompanied with amines which may be partially responsible for the toxicity of the sclerotia.
- N-methyl.β-phenylethylamine is the toxic principle of *Acacia berlandieri* (guajilo), and more than one toxic compound in species of *Lathyrus* appears to be related to β-cyano-L-alanine.

Glycosides

- Glycosides are compounds which yield one or more sugars and one or more other compound (aglycones) when hydrolyzed in vitro by dilute mineral acids or *in vivo* by enzymes.
- The term glucoside has often been used synonymously with glycoside, and this practice continues.
- Critical usage reserves the term glucoside for that particular kind of glycoside in which the sugar component is glucose.
- Purified glycosides are usually bitter, colorless, crystalline solids. Glycosides are much more widely distributed in the plant kingdom than are alkaloids. Many are nontoxic e.g. several of the common non- photosynthetic plant pigments
- Toxicity is a function of the aglycone component, or part of it. A great variety of compounds serve as aglycones in glycosides.

- Toxic glycosides include: cyanogenetic (nitrile) glycosides, goitrogenic substances, irritant oils, coumarin glycosides and steroid (cardiac and saponic) glycosides
- The amount of a particular glycoside elaborated in a plant depends not only on intrinsic factors such as genetics, part of plant, age of plant, and sometimes even sex of plant, but also to a large degree on extrinsic factors such as climate, moisture supply and soil fertility.

(a).Cyanogenetic (nitrile) glycosides

- Glycosides which yield hydrocyanic acid (HCN) upon hydrolysis are termed cyanogenetic or cyanophoric. The glycoside amygdalin is one of the most common. It is found in many members of the *Rosaceae* family.
- The intact glycoside is not toxic. The violent toxicity of the compound is caused solely by its HCN component, acting as a free molecule after hydrolysis. Little free HCN is found in healthy actively growing plants.
- In natural circumstances, hydrolysis is brought about by enzymatic action in the plant or animal. An unknown mechanism blocks or inhibits reaction between enzyme and substrate in healthy plants.
- The frequently observed higher content of free HCN in wilted, frosted or stunted plants may result from the joining of plants enzyme and cyanogenetic glycoside caused by these conditions, with resulting release of free HCN.
- Ruminant animals seem to be more susceptible to HCN poisoning from plants of equal cyanogenetic potential than are monogastric animals and the human being, for the reason that the microflora of the rumen provokes, and ruminal pH encourages greater enzymatic breakdown than that accomplished in non ruminants.
- In ruminants, absorption into the bloodstream takes place directly from the rumen. HCN is a small molecule and is rapidly absorbed and readily excreted by several routes.
- Much is eliminated simply in breathing. Chronic HCN poisoning as it is known in human beings is rare in animals.
- A number of factors must be considered in determining whether cyanide poisoning may be expected to take place. They include: cyanogenetic potential of the plant; amount of free HCN in the plant before ingestion; size and kind of subject; speed of ingestion; and speed of release of HCN during digestion.

- Cyanide is highly reactive and during digestion, may enter reactions which prevent its absorption by the blood.
- Thus, the kind of ingesta present in the digestive tract, and the degree of wetness, are important.
- The amount of ingesta is significant in its diluents effect on entering cyanide.
- Speed of excretion or detoxification within the body is obviously to be considered in estimating whether a toxic level of HCN will develop in the blood.
- There is little difference between toxic and lethal blood HCN levels. Two milligrams HCN per pound of animal per hour is close to the minimum lethal dose, and as a rule of thumb, plants which contain more than 20 mg of HCN per 100 g can be considered potentially dangerous.
- The well known picrate test for cyanide has been adapted for easy field use on plant or stomach-content samples.

Mode of action.

- HCN acts by inhibiting the action of the porphyrin enzyme cytochrome oxidase. This enzyme is a terminal respiratory catalyst linking atmospheric oxygen with metabolic respiration. Thus, HCN poisoning constitutes asphyxiation at the cellular level.
- The ability of the blood to carry oxygen is unimpaired (of diagnostic importance).
- Death usually follows ingestion of a lethal dose within 15 minutes to a few hours.

Management strategies

- Experimentally, it has been possible to protect an animal against upto three times the minimum lethal dose of HCN by prompt injection of sodium thiosulfate and sodium nitrite, but sufficiently prompt treatment is usually unavailable.
- Sodium nitrite is used to convert some of the bloods hemoglobin to methaemoglobin. Methaemoglobin combines preferentially with cyanide in competition with the respiratory enzyme cytochrome oxidase. Sodium thiosulfate converts some cyanide (including that from dissociation of cyanomethaemoglobin) into the relatively non toxic and stable thiocyanate.
- The amount of nitrite injected is critical, since sufficient un altered hemoglobin must remain a necessary minimum amount of oxygen to the tissue; otherwise, nitrite poisoning will result.

- Experiments with mice have shown hydroxo-cobalamin (B12a) as being effective in cyanide poisonings. Large amounts of this molecule, which combines preferentially with the cyanide radical, may be safely used.

Detoxification

- There is evidence that detoxification of cyanide in the body is a rapid and effective process. Thiocyanides are formed in the liver with sulfur from amino acids and other sulfur donors.
- Sheep, by this mechanism, can detoxify at least 2 mg HCN per kilogram body weight per hour.

Symptoms of cyanide poisoning

- In gross aspect, symptoms of cyanide poisoning consist primarily of: early stimulation of respiration; rapidly changing to dyspnea; excitement; gasping; staggering; paralysis; prostration; convulsions; coma and death.
- The mucous membranes of mouth and eye may present evidence of congestion. It is sometimes possible to detect a characteristic odor (of benzaldehyde from breakdown of the aglycone of certain cyanogenetic glycosides) in the ingesta if the subject is examined immediately.
- Content of cyanogenetic glycoside in plants
- The content of cyanogenetic glycoside in a given wild plant or crop may vary widely with a number of external conditions. This variation has been explored most thoroughly in the case of sorghum. Factors such as climate; season; amount of rainfall; fertilization and stage of growth are influencing.
- Heritable strain differences are important in sorghum. Hay made from some plants may be dangerous when cut but may become safe in time, possibly through volatilization of its HCN content.
- Cyanide was first detected in plants in 1803.

Plants with cyanogenetic potential

Scientific name/Species	Common name/example
<i>Acacia gregii</i>	catclaw
<i>Bahia oppositifolia</i>	bahia

<i>Cercocarpus spp.</i>	Mountain mohagany
<i>Florestina tripteris</i>	florestina
<i>Glyceria striata</i>	Fowl mannagrass
<i>Holcus lanatus</i>	Velvet grass
<i>Hydrangea spp.</i>	hydrangea
<i>Linum spp.</i>	flax
<i>Lotus Corniculatus</i>	Birdsfoot trefoil
<i>Manihot esculenta</i>	cassava
<i>Phaseolus lunatus</i>	Lima bean
<i>Prunus spp.</i>	Cherries
<i>Pyrus malus</i>	apple
<i>Sorghum spp.</i>	Sudan grass; Johsongrass
<i>Stillingia treculeana</i>	Queens delight
<i>Suckleya suckleyana</i>	Poison suckleya
<i>Trifolium repens</i>	White clover
<i>Triglochin spp.</i>	Arrow grass
<i>Vicia sativa</i>	Vetch seed
<i>Zea mays</i>	Maize, corn

(b). Goitrogenic substances

- A number of natural substances are known which prevent the thyroid from accumulating inorganic iodide normally, thus inhibiting formation of the thyroid hormone.
- Included are: thiouracil; thiourea; cyanides and sulfonamides. Two additional compounds, thiocyanates and L-5-vinyl-2-thioxazolidone, have been isolated from

plants which have caused stock loss with symptoms of hypothyroidism. Both occur in plants as glycosides.

- L-5-vinyl-2-thioxazolidone can be removed or detoxified in rape seed meal by hot water extraction. Its major effects can be countered by adding the appropriate amount of iodinated protein to the diet.
- HCN released from the cyanogenetic glycoside linamarin is detoxified in the liver by coupling with sulfur forming thiocyanates. Thiocyanate is excreted slowly. It is an iodine responsive goitrogen, suppressing accumulation of iodine in the thyroid. Its effects may be counteracted by iodine therapy.
- Thioxazolidone and thiocyanate cause hyperplastic enlargement of the thyroid and symptoms of hypothyroidism. Ewes fed goitrogenic plants show few signs of hypothyroidism, although greater or lesser enlargement of the thyroid may be observed on post mortem examination. A large fraction of the lambs may be born dead, or if not, will be poorly developed, listless, and seemingly disinterested in nursing.
- Enlarged thyroids may be palpated and are distinctly obvious upon post mortem examination.
- In the case of poultry, a residual goitrogenic effect may be utilized constructively to produce slightly heavier birds on less feed.

Plants containing goitrogenic compounds

Scientific name	Common name
<i>Beta vulgaris var. cicla</i>	chard
<i>Brassica caulorapa</i>	kohlrabi
<i>Brassica hirta</i>	White mustard seed
<i>Brassica napus</i>	Rape seed or meal
<i>Brassica nigra</i>	Black mustard seed
<i>Brassica oleraceae var. acephala</i>	Kale
<i>Var. botrytis</i>	Broccoli
<i>Var. capitata</i>	Cabbage
<i>Var. gemmifera</i>	Brussels sprouts

<i>Var.napobrassica</i>	rutabaga
<i>Brassica pekinensis</i>	Chinese cabbage
<i>Brassica rapa</i>	Turnip root
<i>Glycine max</i>	soybean
<i>Linum usitatissimum</i>	flax

(c). Irritant oils

(i). Mustard oils

- The pungent, sharp taste characteristic of mustard preparations is derived from mustard oils. Mustard oils are *isothiocyanates*. The two best known and most common are allyl isothiocyanate and 3-butenyl isothiocyanate
- Cattle are killed by ingestion of about 0.001 percent of the animal's weight of oil.

Plants whose mustard oil content is held responsible for symptoms of gastroenteritis produced in stock

Scientific name	Common name
<i>Armoracia lapathifolia</i>	horseradish
<i>Brassica hirta</i>	White mustard
<i>Brassica juncea</i>	Indian mustard
<i>Brassica kaber</i>	charlock
<i>Erysimum cheiranthoides</i>	Wormseed mustard
<i>Raphanus raphanistrum</i>	Wild radish
<i>Thlapsi arvense</i>	fanweed

(ii). Protoanemonin

- Several genera in the buttercup family (*Ranunculaceae*) owe their irritant properties to the presence of an innocuous glycoside, ranunculin. Ranunculin readily breaks down to release the aglycone protoanemonin which is volatile, strongly irritant, unstable oil.

Plants producing protoanemonin

Scientific name	Common name
<i>Actaea spp.</i>	baneberry
<i>Anemone spp.</i>	windflower
<i>Caltha palustris</i>	Marsh marigold
<i>Ranunculus spp.</i>	buttercups

(iii). Other irritant oils

- Not all irritant oils are glycosides. A wide variety of chemical compounds have the physical characteristics of irritant oils and are found, usually in relatively small amounts, among plants of diverse relationships.
- Oil of wintergreen (methyl salicylate) is an example. It is found in several members of the *Ericaceae* (heath family) and *Betulaceae* (birch family).
- Species in which such irritant oils may have accounted for, or contributed to, toxicity include *Glechoma hederacea* (gill-over-the-ground) and *Chenopodium ambrosioides* (wormseed).

(d). Coumarin glycosides

- There are several glycosides in the plant kingdom in which the aglycone is a modification of coumarin.
- The sweetclovers (*Melilotus alba*, and *M.officinalis*) contain a coumarin derivative which under certain conditions of spoilage in sweet clover hay polymerizes to form dicoumarol, a hemorrhagic agent. Both natural and synthetic dicoumarol reduce blood prothrombin level in similar fashion and cause the blood to become incapable of clotting.

(e). Steroid glycosides and triterpenoid glycosides

- Most members of both groups possess the physical characteristics by which saponins are recognized. The aglycones themselves may have definite toxic characteristics, but

the sugar portions of the molecules are important in altering or determining the activity of the intact glycoside.

- The sugars are especially important in increasing the solubility of the molecules. Steroid glycosides may be further divided on physiological grounds into those which possess marked ability to stimulate the heart (cardiac glycosides) and those which do not.
- The saponic characteristics of the latter are emphasized in the name by which they are generally designated (saponic glycosides) and in the generic term applied to their aglycones (sapogenins), but they are not unique in possessing the characteristics of saponins.

(i). Cardiac glycosides

- Crude preparations from *Digitalis* spp. (foxglove) have long been used in medicine for their ability to strengthen the action of a weakened heart.
- The activity of these preparations comes from the presence in them of certain glycosides, the aglycones (genins) of which possess a particular steroid configuration.
- Cardioactivity is associated with the presence and specific orientation of an unsaturated lactone ring and hydroxyl group in the aglycone.
- Rate of absorption from the digestive tract varies markedly among glycosides and is further influenced by the digestive milieu. In therapeutic amount, they act directly on heart musculature to increase the force of contraction in systole, and on its vagus innervations, to decrease the rate of beat.
- Overdose produces nausea; dizziness; blurred vision and diarrhea.

Poisonous plants containing cardiac glycosides

Scientific name	Common name
<i>Adonis</i> spp.	Pheasants eye
<i>Apocynum</i> spp.	dogbane
<i>Convallaria majalis</i>	Lily of the valley
<i>Digitalis purpurea</i>	foxglove
<i>Nerium oleander</i>	oleander

<i>Thevetia peruviana</i>	Be still tree
<i>Urginea maritima</i>	squill

(ii). Saponins

- The noncardioactive steroid glycosides and the triterpenoid glycosides may be considered together under this term, since their saponic character seems to be the basis for much of their physiological activity.
- Saponins are large molecules which form a colloidal solution and produce a non alkaline, soapy froth or foam when shaken in water. The discovery of steroid configuration in some saponins, suggesting potential value as precursors for sex and cortical hormones, led to extensive investigations which have resulted in a better understanding of this group of compounds.
- Saponins occur in plants as amorphous glycosides in which the aglycone may be termed as sapogenin. The sugars associated with them in the glycosides include: glucose; galactose; rhamnose and arabinose
- The saponin content of a particular species commonly varies with part of the plant, season, and stage of growth.

Mode of action

- The physiological reaction which is believed to account for the toxicity of both triterpenoid and steroid saponins is the destruction of erythrocytes by lysis. The hemolytic effect is apparently the result of reaction between saponin and cholesterol in the cell membrane, causing it to burst.

Absorption of saponins

- Saponins are not readily absorbed into the bloodstream through the uninjured digestive tract. To be toxic, therefore, they must possess, or be accompanied in the plant by a substance which possesses, irritant properties sufficient to injure the wall of the digestive tract and permit absorption.
- Under such circumstances, the major symptoms and lesions are those of severe gastroenteritis.
- Saponins, by themselves, may contribute to gastrointestinal irritation. Administered parenterally, some saponins produce marked visceral vasodilation.

Poisonous plants containing saponins

Scientific name	Common name
<i>Agrostemma githago</i>	Corn cockle
<i>Aleurites spp.</i>	Tung tree
<i>Fagus sylvatica</i>	beech
<i>Hedera helix</i>	English ivy
<i>Linum neomexicanum</i>	Yellow pine flax
<i>Medicago sativa</i>	alfafa
<i>Phytolaca americana</i>	pokeweed
<i>Saponaria spp.</i>	Bouncing bet, cow cockle
<i>Sesbania spp.</i>	Coffeeweed; rattlebox

Phytotoxins

- Phytotoxins (also called toxalbumins) are protein molecules of high toxicity produced by a smaller number of plants.
- Phytotoxins are large, complex molecules similar to bacterial toxins in structure and causing somewhat similar physiological reactions. Like bacterial toxins they act as antigens, eliciting an antibody response in the reacting subject.
- In vitro, phytotoxins cause agglutination of erythrocytes. This does not seem to be the basis of their extreme toxicity.
- Phytotoxins function in vivo as potent proteolytic enzymes, owing their toxicity to breakdown of critical natural proteins and accumulation of ammonia.
- True immunity can be produced through administration of immunizing doses of the phytotoxin in increasing strength. Passive immunity can be conferred by the injection of antisera. Antisera for phytotoxins are commercially unavailable because of the rarity of the cases.
- Phytotoxins are nondialyzable, heat labile and can be positively identified by precipitin reactions with sera containing known antibodies. Toxic castor bean press cake can be made nontoxic simply by heating.

- There is considerable variation in susceptibility to phytotoxins with species of animal and individual subject. The minimum lethal dose of ricin, the phytotoxin from castor bean, when administered by injection, may be as small as 0.00000001 per cent of an animal's weight; orally it is several hundred times less toxic.
- Unlike some bacterial toxins and venoms, phytotoxins are more or less readily absorbed through the wall of the digestive tract. Usually, a distinct and characteristic lag period occurs between ingestion and appearance of symptoms.
- Symptoms largely are those associated with gastrointestinal irritation. Lesions consist of hemorrhagic gastrointestinal inflammation and edematous swelling in several organs.

Plants containing phytotoxins

Scientific name	Common name
<i>Abrus precatorius</i>	Precatory bean
<i>Aleurites fordii et spp.</i>	Tung tree
<i>Jatropha curcas</i>	barbadosnut
<i>Ricinus communis</i>	Castor bean
<i>Robinia pseudoacacia</i>	Black locust

Compounds causing photosensitivity

- Photosensitivity is a condition in which animals become hypersensitive to light owing to the presence of some abnormal substance in the peripheral circulation. The condition may be primary, secondary or congenital.

(i). Primary photosensitization

- It is brought about by ingestion of some photodynamic substance such as hypericin from *Hypericum perforatum* (St. Johns Wort) or fagopyrin from *Fagopyrum esculentum* (Buckwheat).
- Black skinned animals or those kept in subdued light, suffer no ill effects, but when exposed to daylight, particularly bright sunlight, light skinned animals or those with white patches develop a syndrome which consists largely of a dermatitis sometimes associated with conjunctivitis.

- The areas of skin usually affected are those most exposed to light and lacking the protection of coat or pigments.
- Erythema is the first change, and this rapidly develops into oedema.
- In cattle, there is usually little oedema, the white parts of the skin sloughing off, leaving slow healing wounds, which even after they have healed show hairless scars.
- The condition seldom causes death and soon clears up if the plant containing the sensitizing agent is withdrawn.
- Primary photosensitization is also caused by drugs used for therapeutic purposes, such as phenothiazines, the actual sensitizing agent being phenothiazine sulphoxide, a metabolite of the drug.

(ii). Secondary or hepatogenous photosensitivity.

- It is caused by the ingestion of some substance, frequently of vegetable origin, which gives rise to liver dysfunction and obstruction of the bile duct.
- The liver toxin itself has no photodynamic activity, but the damage it causes in the liver allows substances normally eliminated in the bile to reach the peripheral circulation and give rise to photosensitization.
- There are two distinct sets of lesions, the first, which may include depression, anorexia, diarrhea and icterus, being due to the damage done to the liver by the toxin, and the second, which resembles those in primary photosensitivity, being caused by the presence in the skin of some substance normally eliminated in the bile.
- The most common of these compounds is phylloerythrin, a breakdown product from chlorophyll. The liver damage is much more serious than the photosensitivity, and it is possible for an acutely poisoned animal to die before the latter develops.
- In an animal kept in the dark, or on a chlorophyll free diet, photosensitivity will not develop at all.

Plants causing secondary photosensitization

Scientific name	Common name
<i>Agave lecheguilla</i>	lechuguilla
<i>Brassica napus</i>	Cultivated rape

<i>Lantana spp.</i>	lantana
<i>Nolina texana</i>	sacahuiste
<i>Panicum spp.</i>	Panic grasses
<i>Tetradymia spp.</i>	horsebrush
<i>Tribulus terrestris</i>	Puncture vine

Nitrates-Nitrites

- Many crop plants (especially oat hay, corn and sorghum), vegetables and weeds (especially of the amaranth (*Amaranthaceae*), goosefoot (*Chenopodiaceae*), mustard (*Cruciferae*) composite (*Compositae*) and nightshade (*Solanaceae*) families contain nitrates at a potentially toxic level.
- Plants containing more than 1.5% nitrate (as KNO₃, dry weight) may prove lethal to livestock.
- Nitrate poisoning can be produced in animals by ingestion of nitrate fertilizers, machine oil, and natural well and pond water of high nitrate content, as well as by plants and hay or silage made from them and in human beings from foods improperly preserved with nitrates.
- Growth under drought conditions and lessened light tend to promote increased nitrate content. Nitrate accumulates in vegetative tissues. The grain (fruit) remains safe.
- Treatment with herbicide 2,4-D, has been shown to produce two unexpected results: One, a number of normally unpalatable weeds, such as pigweeds (*Amaranthus spp.*), ragweed's (*Ambrosia spp.*) and jimson weed (*Datura stramonium*) become palatable.
- Second, the resulting upset in nitrogen metabolism in the plant may cause it to accumulate nitrate to a toxic level.
- Both brucine and diphenylamine tests for nitrates may be adapted for use by the veterinarian in the field. For the latter, 500 mg of diphenylamine in 20 ml of water and adding concentrated sulfuric acid (carefully!) to make 100 ml. The stock solution should be stored in a brown bottle.
- It may be used without dilution to detect small amounts of nitrates or after dilution with an equal volume of 80% sulfuric acid to serve for rough estimation of the presence or absence of physiologically dangerous amounts of nitrates.

- The development of a blue color (precipitate) within 30 minutes constitutes a positive test.

Poisonous plants containing fluoroacetate

- Some plants are known to concentrate sodium fluoroacetate, one of the most poisonous substances known.
- In Kenya, *Dichapetalum cymosum* is found in the coastal region, where it is known as “ludi” locally. A few leaves are capable of killing a big bull.

Oxalates

- Oxalic acid ingested as a chemical is corrosive to animal tissues which it reaches. Under natural conditions, however, oxalic acid is toxic, not because of its acidity but because of the reactions of the oxalate ion.
- This is the only organic acid of plants which is toxic to livestock under natural conditions. It occurs in plants in the form of soluble (sodium and potassium) and insoluble (calcium) oxalates or acid oxalates.
- Many plants contain small amounts of soluble oxalates; only a few have enough to be dangerous. Plants, such as *Rumex*, with sap pH of about 2, contain mostly acid oxalates; those, such as many *Chenopodiaceae* (goose-foot family), in which the pH is 5-6, contain mostly oxalate salts.
- The small natural amounts of insoluble oxalates in the diet are not absorbed and are excreted without effect. Soluble oxalates may be absorbed rapidly, especially in the non ruminant. Ruminants are relatively resistant to oxalate poisoning due to the capacity of the normally functioning rumen to alter chemically and detoxify soluble oxalates reaching it in the diet.
- Detoxification accompanies reactions of oxalates in which carbonates and bicarbonates are formed.

Absorption

- Absorption of soluble oxalates into the bloodstream correlates directly with drop in level of ionic calcium in the serum. Removal of calcium ion by precipitation produces effects which may be assigned not only to unavailability of calcium but also to imbalance in mono and divalent cations and perhaps to pH changes.
- These include nervous symptoms, reduced coagulability of the blood; and acute nephritis. Drop in serum calcium is not as simple as it first appears. Its effects cannot be reversed by administration of calcium gluconate.

- Moderate amounts of soluble oxalates are readily excreted, but larger concentrations result in precipitation of oxalate crystals in the kidney tubules.
- Precipitates may take the form of small rhomboidal crystals, or of rosettes of crystals completely occluding the lumen of the tubule. In mild cases, some tubules remain functional. In severe cases, the lumens of almost all tubules are plugged and symptoms are those of renal insufficiency.
- Necrosis of epithelial cells occurs where they contact oxalate crystals; the remainder of the kidney tissue remains apparently healthy. Calculi may be formed in the urinary tract.

Symptoms of oxalate poisoning

- Ingestion by sheep of a toxic dose of plants containing soluble oxalates is followed, usually within 2-6 hours, by symptoms of dullness, colic, depression, dyspnea; prostration; and coma. Death intervenes about 10 hours after ingestion.

Post mortem findings

- Excess fluid in abdominal and thoracic cavities, diffuse and petechial hemorrhages throughout the digestive tract and in the serous membranes, and emphysema of the lungs which also sometimes contain inspired ingesta.
- The cortex and medulla of the kidney, both dark red in color, are separated by a line of gray resulting from the accumulation of oxalate crystals in the uriniferous tubules.
- Dicalcium phosphate fed free choice at 25% of the usual salt ration seems to offer complete protection against the usual losses.

NB: High calcium in the diet tends to limit oxalate absorption, so high oxalate intake tends to reduce sharply the amount of calcium absorbed from a diet containing adequate amounts.

Plants which may contain dangerous amounts of soluble oxalates

Scientific name	Common name
<i>Beta vulgaris</i>	Beet, mangold
<i>Halogeton glomeratus</i>	halogeton
<i>Oxalis spp.</i>	Sorrel; soursob

<i>Portulaca oleracea</i>	purslane
<i>Rheum rhaponticum</i>	rhubarb
<i>Rumex spp.</i>	Sorrel; dock
<i>Salsola pestifer</i>	Russian thistle
<i>Sarcobatus vermiculatus</i>	greasewood

Fungicidal toxin: Persin

Ingestion of avocado (*Persea americana*) has been associated with myocardial necrosis in mammals and birds and with sterile mastitis in lactating mammals. Cattle, goats, horses, mice, rabbits, guinea pigs, rats, sheep, budgerigars, canaries, cockatiels, ostriches, chickens, turkeys, and fish are susceptible. Caged birds appear more sensitive to the effects of avocado, while chickens and turkeys appear more resistant. A single case report exists of 2 dogs developing myocardial damage secondary to avocado ingestion.

Etiology

Ingestion of fruit, leaves, stems, and seeds of avocado have been associated with toxicosis in animals; leaves are the most toxic part. The Guatemalan varieties of avocado have been most commonly associated with toxicosis.

When purified, the toxic principle in avocado, persin, causes mastitis in lactating mice at 60–100 mg/kg, and doses >100 mg/kg result in myocardial necrosis. Goats develop severe mastitis when ingesting 20 g of leaves/kg, whereas 30 g of leaves/kg results in cardiac injury. Acute cardiac failure developed in sheep fed avocado leaves at 25 g/kg for 5 days; 5.5 g/kg of leaves fed for 21 days or 2.5 g/kg for 32 days caused chronic cardiac insufficiency. Budgerigars fed 1 g of avocado fruit developed agitation and feather pulling, while 8.7 g of mashed avocado fruit resulted in death within 48 hr.

Pathogenesis

Avocado causes necrosis and hemorrhage of mammary gland epithelium of lactating mammals and myocardial necrosis in birds and mammals. Persin isolated from avocado leaves has caused lesions similar to those reported in natural cases.

Clinical Findings

In lactating animals, mastitis occurs within 24 hr of exposure to avocado, accompanied by a 75% decrease in milk production. Affected mammary glands are firm, swollen, and produce watery,

curdled milk. Lactation may provide a degree of protection against myocardial injury at lower doses. In non lactating mammals, or at higher doses, myocardial insufficiency may develop within 24–48 hr of ingestion and is characterized by lethargy, respiratory distress, subcutaneous edema, cyanosis, cough, exercise intolerance, and death. Horses may develop edema of the head, tongue, and brisket. Birds develop lethargy, dyspnea, anorexia, subcutaneous edema of neck and pectoral regions, and death.

Lesions

Mammary glands are edematous and reddened, with watery, curdled milk. In animals with cardiac insufficiency, there is congestion of lungs and liver, often with dependent subcutaneous edema. There may be free fluid within the abdominal cavity, pericardial sac, and thoracic cavity; pulmonary edema may be present. The heart may contain pale streaks. Histopathologic lesions in the mammary gland include degeneration and necrosis of secretory epithelium, with interstitial edema and hemorrhage. Myocardial lesions include degeneration and necrosis of myocardial fibers, which are most pronounced in ventricular walls and septum; interstitial hemorrhage and/or edema may be present. In horses, symmetric ischemic myopathy of head muscles and tongue, as well as ischemic myelomalacia of the lumbar spinal cord, have been described.

Diagnosis

Diagnosis of avocado toxicosis relies on history of exposure and clinical signs. There are no readily available specific tests that will confirm diagnosis. Differential diagnoses include other causes of mastitis (eg, infectious) and other myocardial disorders, including ionophore toxicosis, yew toxicosis, vitamin E/selenium deficiency, gossypol, cardiac glycoside toxicosis (eg, oleander), cardiomyopathy, and infectious myocarditis.

Treatment

NSAID and analgesics may benefit animals with mastitis. Treatment for congestive heart failure (eg, diuretics, antiarrhythmic drugs) may be of benefit, but may not be economically feasible in livestock.