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A DETAILED REVIEW ON SOLANACEAE FAMILY

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ABSTRACT

This family is called as nightshades family which is a family of flowering plants. Present review covers 25 important genus and important species in respective genus. The most economically important genus of the family is *Solanum*. Most members of the Solanaceae are erect or climbing, annual or perennial herbs, but shrubs are not uncommon and there are a few trees Eight genera, Solanum, Lycianthes, Cestrum, Nolana, Physalis, Lycium, Nicotiana, Brunfelsia contain more than 60% of the species. Many members of the family contain potent alkaloids, and some are highly toxic, but many cultures eat nightshades, in some cases as staple foods. The tropanes are the most well-known of the alkaloids found in the Solanaceae. Besides this scopolamine, atropine, hyoscyamine, and nicotine are also present. Members of Solanaceae provide a variety of culinary, medicinal, and ornamental values. The major activity shown by most of the species is poisoning and psychotropic activity.

KEYWORDS: Solanaceae, nightshades, solanum, alkaloids, hyoscyamine.

INTRODUCTION

The family belongs to the order Solanales, in the asterid group dicotyledons (Magnoliopsida).The Solanaceae consists of about 98 genera and some 2,700 species with a great diversity of habitats, morphology and ecology. Eight genera, Solanum, Lycianthes, Cestrum, Nolana, Physalis, Lycium, Nicotiana, Brunfelsia contain more than 60% of the species. The name Solanaceae derives from the genus Solanum, "the nightshade plant". The etymology of the Latin word is unclear. The name may come from a perceived resemblance of certain solanaceous flowers to the sun and its rays. At least one species of *Solanum* is known as the "sunberry". Alternatively, the name could originate from the Latin verb *solari*, meaning "to soothe".[1]

DISTRIBUTION

The family has a worldwide distribution, being present on all continents except Antarctica. The greatest diversity in species is found in South America and Central America. Most members of the Solanaceae are erect or climbing, annual or perennial herbs, but shrubs are not uncommon and there are a few trees. The Solanaceae contain 98 genera and some 2,700 species. Despite this immense richness of species, they are not uniformly distributed between the genera. The eight most important genera contain more than 60% of the species, as shown in the Table 1 below. *Solanum* – the genus that typifies the family - includes nearly 50% of the total species of the solanaceas.[1]

Table 1: List of different Genera of Solaneceae Family with approximate no. of species[2]

Genera	Approximate number of species
Solanum	1,330
Lycianthes	200
Cestrum	150
Nolana	89
Physalis	85
Lycium	85
Nicotiana	76
Brunfelsia	45
Estimated number of species in the family	2,700

MORPHOLOGY

Leaves: The leaves vary greatly in shape but are usually simple, although sometimes highly lobed. They are alternate and never have stipules. The inflorescence is generally cymose and axillary, but may be reduced to a single flower. The flowers are bisexual, usually radially symmetric, and usually 5-merous. The calyx is united, at least at the base, and sometimes becomes inflated in fruit. The corolla is also united but its shape varies from long and tubular to rotate or campanulate. It is usually radially symmetric, but there are some bilaterally symmetric genera. There are 5 (rarely 4-8) epipetalous stamens that alternate with the corolla lobes. The anthers are sometimes touching but are never fused. The gynaecium consists of a single pistil, usually with 2 locules and numerous ovules. The

fruit is a usually a berry but quite frequently a dry capsule.[3,4]

Axial (stem, wood) anatomy

Cork cambium present; initially deep-seated, or initially superficial. Nodes unilacunar (with 2 or 3 traces). Primary vascular tissues in a cylinder, without separate bundles; bicollateral. Internal phloem universally present (as strands, or a continuous ring). Secondary thickening developing from a conventional cambial ring (usually), or anomalous. The anomalous secondary thickening when present, via concentric cambia, or from a single cambial ring.[5]

Inflorescence, floral, fruit and seed morphology

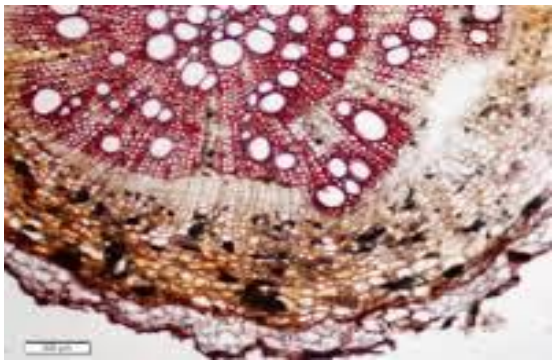
Flowers solitary, or aggregated in 'inflorescences'. The ultimate inflorescence units when present, apparently cymose. Inflorescences terminal, or axillary, or leaf-opposed (occasionally). Flowers small to medium-sized; fragrant (e.g. *Nicotiana*), or malodorous (e.g. *Anthocercis*, if so considered), or odourless (mostly); regular (usually, more or less), or somewhat irregular to very irregular. The floral irregularity (when noticeable) involving the perianth, or involving the androecium, or involving the perianth and involving the androecium. Flowers mostly (4–)5 merous; cyclic; tetracyclic. Free hypanthium absent. Hypogynous disk usually present; intrastaminal.

Perianth with distinct calyx and corolla; 10 (nearly always), or 8, or 11–14; 2 whorled; isomerous, or anisomerous. Calyx (4–)5(–7); 1 whorled; gamosepalous. Calyx lobes markedly shorter than the tube to markedly longer than the tube. Calyx regular (usually), or unequal but not bilabiate; persistent; accrescent, or non-accrescent. Corolla (4–)5(–7); 1 whorled; gamopetalous. Corolla lobes markedly shorter than the tube to markedly longer than the tube. Corolla contorted and plicate (usually), or imbricate, or valvate, or contorted; rotate, or campanulate, or funnel-shaped, or tubular; regular (usually, more or less), or bilabiate (rarely), or unequal but not bilabiate (sometimes).[5]

Fruit fleshy, or non-fleshy; dehiscent, or indehiscent; a capsule, or a berry, or a drupe. Capsules septicidal (commonly), or loculicidal, or valvular, or circumscissile (*Hyoscyamus*). Seeds endospermic (usually). Endosperm oily (usually), or not oily (rarely starchy). Seeds not conspicuously hairy. Seeds with starch (rarely), or without starch. Cotyledons 2; semi-cylindric. Embryo achlorophyllous (13/21); straight, or straight to curved, or curved (curved through more than a semicircle to annular in Nicandreae, Solaneae and Datureae, but straight to only slightly curved in Cestreae and Salpiglossideae).

MICROSCOPY

Root: Lignified, Cork cambium of 2-4 diffused rows of cells, Secondary cortex about twenty layers of compact parenchymatous cells, Phloem consists of sieve tubes, companion cells, phloem parenchyma, Cambium 4-5 rows of tangentially elongated cells, Secondary xylem hard forming a closed vascular ring separated by multiseriate medullary rays, a few xylem parenchyma, Vessels with bordered pits and horizontal perforations. Fibres aseptate with pointed ends. Starch grains abundant, simple, mostly spherical, reniform – oval with central hilum. Microcrystals in parenchyma cells.[6,7]

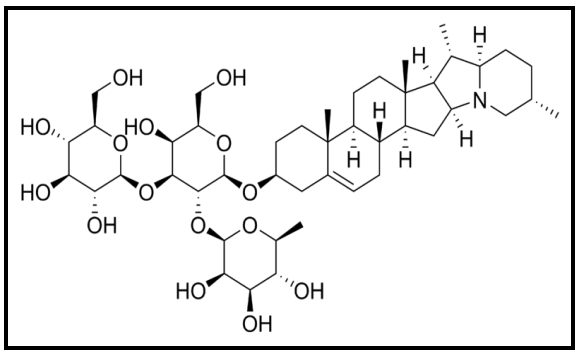


T.S of root of *Withania somnifera*

CHEMISTRY: Alkaloids are nitrogenous organic substances produced by plants as a secondary metabolite and which have an intense physiological action on animals even at low doses. Solanaceae are known for having a diverse range of alkaloids. To humans, these alkaloids can be desirable, toxic, or both. The tropanes are the most well-known of the alkaloids found in the Solanaceae. The plants that contain these substances have been used for centuries as poisons. However, despite being recognized as poisons, many of these substances have invaluable pharmaceutical properties. The many species contain a variety of alkaloids that can be more or less active or poisonous, such as scopolamine, atropine, hyoscyamine, and nicotine. They are found in plants such as the henbane (*Hyoscyamus albus*), belladonna (*Atropa belladonna*), datura or jimson (*Datura stramonium*), mandrake (*Mandragora autumnalis*), tobacco, and others. Some of the main types of alkaloids are

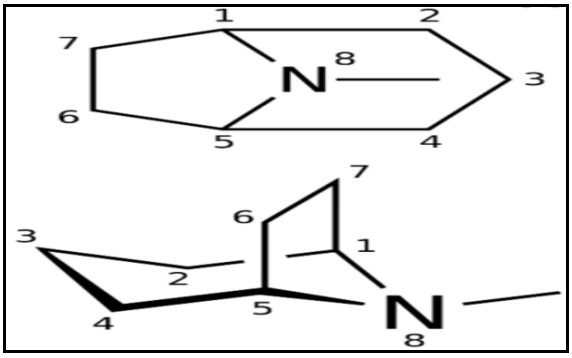
Solanine: A toxic glycoalkaloid with a bitter taste, it has the formula $C_{45}H_{73}NO_{15}$. It is formed by the alkaloid solanidine with a carbohydrate side chain. It is found in leaves, fruit, and tubers of various Solanaceae such as the potato and tomato. Its production is thought to be an adaptive defence strategy against herbivores. Substance intoxication from solanine is characterized by gastrointestinal disorders (diarrhoea, vomiting, abdominal pain) and neurological disorders (hallucinations and headache). The median lethal dose is between 2 and 5 mg per kg of body weight. Symptoms become manifest 8 to 12 hr after ingestion. The amount of these glycoalkaloids in potatoes, for example, varies significantly depending of environmental conditions during their cultivation, the length of storage, and the variety. The average glycoalkaloid concentration is 0.075 mg/g of potato.[2] Solanine has occasionally been

responsible for poisonings in people who ate berries from species such as *Solanum nigrum* or *Solanum dulcamara*, or green potatoes.[3],[4,8,9]



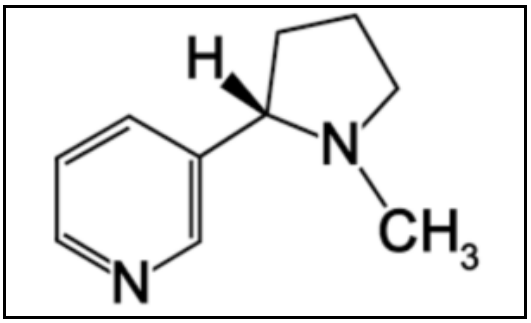
Structure of Solanin

- ***Tropanes:*** The term "tropane" comes from a genus in which they are found, *Atropa* (the belladonna genus). *Atropa* is named after the Greek Fate, Atropos, who cut the thread of life. This nomenclature reflects its toxicity and lethality. They are bicyclic organic nitrogen compounds (IUPAC nomenclature: 8-Methyl-8-azabicyclo octane), with the chemical formula of $C_8H_{15}N$. These alkaloids include, among others, atropine, cocaine, scopolamine, and hyoscyamine. They are found in various species, such as mandrake *(Mandragora autumnalis)*, black henbane or stinking nightshade *(Hyoscyamus niger)*, belladonna *(Atropa belladonna)* the stramonium *(Datura stramonium*) and *Brugmansia* species, as well as many others in the Solanaceae family.[10] Pharmacologically, they are the most powerful known anticholinergics in existence, meaning they inhibit the neurological signals transmitted by the endogenous neurotransmitter, acetylcholine. More commonly, they can halt many types of allergic reactions. Symptoms of overdose may include dry mouth, dilated pupils, ataxia, urinary retention, hallucinations, convulsions, coma, and death. Atropine, a commonly used ophthalmological agent, dilates the pupils and thus facilitates examination of the interior of the eye. Despite the extreme toxicity of the tropanes, they are useful drugs when administered in extremely small dosages. They can reverse cholinergic poisoning, which can be caused by overexposure to organophosphate insecticides and chemical warfare agents such as sarin and VX. Scopolamine (found in *Hyoscyamus muticus* and *Scopolia atropioides*), is used as an antiemetic against motion sickness or for people suffering from nausea as a result of receiving chemotherapy.[11,12] Scopolamine and hyoscyamine are the most widely used tropane alkaloids in pharmacology and medicine due to their effects on the parasympathetic nervous system. Atropine has a stimulant effect on the central nervous system and heart, whereas scopolamine has a sedative effect. These alkaloids cannot be substituted by any other class of compounds, so they are still in demand. This is one of the reasons for the development of an active field of research into the metabolism of the alkaloids, the enzymes involved, and the genes that produce them. Hyoscyamine 6-β hydroxylase, for example, catalyses the hydroxylation of hyoscyamine that leads to the production of scopolamine at the end of the tropane's biosynthetic pathway. This enzyme has been isolated and the corresponding gene cloned from three species: *H. niger*, *A. belladonna* and *B. candida*.[13,14]



Structure of Tropane

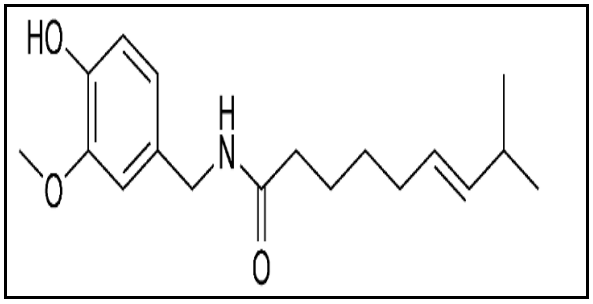
Nicotine: Nicotine (IUPAC nomenclature (S)-3-(1-methylpyrrolidin-2-il) pyridine) is a pyrrolidine alkaloid produced in large quantities in the tobacco plant (*Nicotiana tabacum*), but is also found in lower concentrations in other species such as the potato, tomato, and pepper. Its function in a plant is to act as a defence against herbivores, as it is an excellent neurotoxin, in particular against insects. In fact, nicotine has been used for many years as an insecticide, although its use is currently being replaced by synthetic molecules derived from its structure. At low concentrations, nicotine acts as a stimulant in mammals, which causes the dependency in smokers. Like the tropanes, it acts on cholinergic neurons, but with the opposite effect (it is an agonist as opposed to an antagonist). It has a higher specificity for nicotinic acetylcholine receptors than other ACh proteins.[14,15]



Structure of Nicotine

Capsaicin: Capsaicin (IUPAC nomenclature 8-methyl-N-vanillyl-*trans*-6-nonenamide) is structurally different from nicotine and the tropanes. It is found in species of the genus *Capsicum*, which includes chillies and habaneros and it is the active ingredient that determines the Scoville rating of these spices. The compound is not noticeably toxic to humans. However, it stimulates specific pain receptors in the majority of mammals, specifically those related to the perception of heat in the

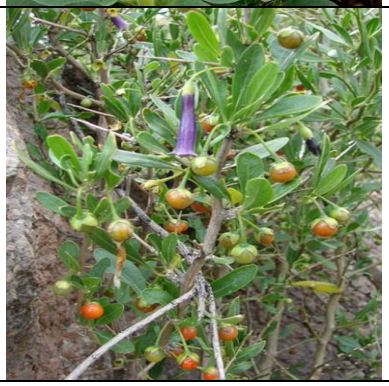
oral mucosa and other epithelial tissues. When capsaicin comes into contact with these mucosae, it causes a burning sensation little different from a burn caused by fire. Capsaicin affects only mammals, not birds. Pepper seeds can survive the digestive tracts of birds; their fruit becomes brightly coloured once its seeds are mature enough to germinate, thereby attracting the attention of birds that then distribute the seeds. Capsaicin extract is used to make pepper spray, a useful deterrent against aggressive mammals.[16]



Structure of Capsaicin

Table No. 1 Different genus with representing plant species of Solanaceae family[5,7,9,15,14,13,12]

Sr No	Genus	Species	Image of the species	Part used	Chemical constituents	Principle uses
1.	Acnistus	*Acnistus arborescenes*		Extracts of plant	Withaferin A and withacnistin	Anti–tumor agent, diuretic
2.	Atropa	*Atropa belladonna*		Roots	Hyoscyamine, atropine, starch, atrosine, scopolamine	Narcotic, diuretic, sedative, antispasmodic, mydriatic.
3.	Browallia	*Browallia speciosa*		Whole plant	Withanolides	Garden ornamental
4.	Brugmansia	*Brugmansia arborea*		Flowers	Tropane alkaloids, hyoscyamine, atropine and scopolamine.	Spasmolytic, anti-asthmatic, anticholinergic, narcotic and anesthetic.

5.	Capsicum	*Capsicum annum*		Fruits and leaves	Capsaicin, capsanthin, carotene, thiamine and ascorbic acid	Carminative, Appetizer, stomachic, counter irritant the treatment of rheumatism, lumbago and neuralgia.
6.	Cestrum	*Cestrum nocturnum*		Leaves and flowers	sapogenin steroids tigogenine, smilagenine, yuccagenine. Traces of nicotine. It also contains alkaloids, anthraquinones, cardiac glycosides, carbohydrates, flavonoids, phenol, tannins and terpenoids.	Antiepilepsy
7.	Cyphomandra	*Cyphomandra betacea*		Fruits	Flavonoids, anthocyanins, phenols, carotenoids, withanolides.	Anticholinesterase Antioxidative
8.	Datura	*Datura metel*		Plant	hyoscine(scopolamine)	Parasympatholytic Anticholinergic and CNS depressant .In cerebral excitement, asthma and cough.
9.	Dunalia	*Dunalia spinosa*		Fruits, flowers and leaves	(E)-aurone rutinoside (dunaurone), lupeol, betasitosterol,scopoletin, quercetin and withaferin A.	Medicine for toothaches, Antimicrobial and antioxidant.

10.	Fabiana	*Fabiana imbricata*		Leaves and flowers	Camphor oil, the coumarin scopoletin and alkaloids.	To treat diseases of the kidneys and urinary tract. Also as a potent diuretic and as an antiseptic.
11.	Hyoscyamus	*Hyoscyamus niger*			Tropane alkaloids hyoscyamine, scopolamine, and atropine. Non-alkaloids constituents such as withanolide steroids, lignanamides, tyramine derivative, steroidal saponins, glycosides, coumarinolignan, and flavonoids.	Analgesic, anti-inflammatory, antipyretic, anticonvulsant, spasmolytic, antidiarrhoeal, antisecretory, bronchodilatory, urinary bladder relaxant, hypotensive, cardiodepressant , vasodilator, antitumor, and feeding deterrent properties.
12.	Iochroma	*Iochroma cyaneum*		All parts	Alkaloids and hallucinogens	Toxic if ingested any way. Grown as an ornamental.
13.	Jaborosa	*Jaborosa integrifolia*		Whole plant	Steroid-derived compounds called withanolides.	Antifeedant effects.
14.	Jaltomata	*Jaltomata procumbens*		Fruits and roots	Alkaloids	The fruits are reportedly edible and have been used to make jams. Root used as a medicinal tea (boiled) to treat stomach ailment.

15.	Lycium	*Lycium barbarum*		Whole berry, juice.	Beta-sitosterol, betaine, beta carotene, niacin, pyridoxine, acorbic acid.	Treatment for sore eyes and inflammation. To treat conditions such as male infertility, promotion of weight loss and general longevity.
16.	Lycopersicon	*Lycopersicon esculentum*		Fruits and pulp	All-trans-lycopene, cis-lycopene, phytoene, phytofluene, sterols, tocopherols, carotenoids.	For liver health, regular use of tomato reduced risk of contracting cancer diseases.
17.	Nicandra	*Nicandra physalodes*		Whole plant	Withanolides such as Nicandrenone, pyrrolidine alkaloids (the roots contain 0.1% Hygrine) and some calystegines.	As an ornamental plant. Have insect repellent properties.
18.	Nicotiana	*Nicotiana tobacum*		Leaves,flowers and seeds	Piperidine type of alkaloids, among which the most prominent is nicotine. The other alkaloids are nornicotine and anabasine.	Stimulant effects on heart and nervous system, powerful quick acting poison. Rectified tobacco seed oil is used as edible oil.
19.	Petunia	*Petunia axillaris*		Flowers	Tropane alkaloids	For ornamental purposes. Flowers extract given to the horses for the remedy of skin problem mostly.

20.	Physalis	*Physalis minima*		Leaves, fruits and flowers	Withanolides. Tropane alkaloids (hyoscyamine, scopolamine)	To treat stomachache and constipation, asperient, diuretic.
21.	Scopolia	*Scopolia carniolica*		Dried rhizomes and roots	Scopolamine, cuscohygrine, hysocyamine, atroscine (inactive scopolamine)	sedative and mydriatic, as a cerebral tranquilizer, effective in alleviating sexual stimulation, to treat seizures of the alimentary tract, applied externally to alleviate rheumatic or arthritic pain.
22.	Solandra	*Solandra maxima*		–	Hallucinogenic tropane alkaloids and essential oils.	It was once used by Huichol of Mexico and other tribes of the region where it is known by name “Kieli” or “Kieri” with some archaeological evidence supporting the theory that its use predates that of “Peyote”.
23.	Solanum	*Solanum khasianum*		Berries and seeds	Solasodine, solakhasianin	As precursor for steroidal synthesis, as sex hormones, oral contraceptives.
24.	Vestia	*Vestia foetida*		Whole plant	Tropane alkaloids	For ornamental purposes.

25.	Withania	*Withania somnifera*		Roots, leaves and infusion.	Withanolides, glycowithanolides and alkaloids. These include withanone, withaferin A, withanolides I, II, III, A, B, E, F, G, H, I, J, K, L, M, WS-I, P and S, withasomidienone and alkaloids viz. Cuscohygrine, anahygrine, tropine, pseudotropine, anaferine, isopellatierine and 3-trophyltigloate.	GABA–mimetic Cognitive, Thyrotropic, Immunomodulator, Hypolipidemic, Anti-carcinogenic and y radiosensibilizer

Uses

Members of Solanaceae provide a variety of culinary, medicinal, and ornamental values.

In terms of culinary value, the most important species of this family for the global diet is the potato or *Solanum tuberosum*, whose carbohydrate-rich tubers have been a staple food in many times and places, and which is one of the most grown crops today. In many genera, the fruits are the desirable item, for example, tomatoes, tomatillos, eggplants, uchuva, and peppers, such as chili pepper.[17]

Medicinally, as well as in terms of poisoning and psychotropic effects, members of Solanaceae have been prized for their alkaloid content and used throughout history. Important drug plants include deadly nightshade or belladonna *(Atropa belladonna)*, jimson weed *(Datura stramonium)*, henbane *(Hyoscyamus niger)*, and tobacco *(Nicotiana tabacum)*. Mandrake, the common name for members of the plant genus *Mandragora*, contains deliriant hallucinogenic tropane alkaloids such as hyoscyamine and the roots sometimes contain bifurcations causing them to resemble human figures, leading to this plant being used in magic rituals and neopagan religions such as Wicca.[18,19]

As ornamental plants, the genera *Petunia*, *Schizanthus* (butterfly flower), *Salpiglossis* (painted or velvet tongue), and *Browallia* (Bush violet, Jamaican forget-me-not) are well-known.

Some plants also are the focus of extensive biological study as model experimental organisms, including the petunia, tobacco plant, tomato, and potato.

The Solanaceae consists of about 98 genera and some 2,700 species with a great diversity of habitats, morphology and ecology, some selected genus and principal species are mentioned in the Table 1.

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