

A Systematic Review on Solanaceae Family

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ABSTRACT:

The Solanaceae family is known as "the night shade family" since it is descended from the genus Solanum. There are 98 genera and 2700 species. The plants are found in South and Central America. Leaves are alternating, spiral, and exstipulate. The flowers are bisexual, actinomorphic, and zygomorphic only infrequently. Cork cambium is found in plants of Solanaceae family. The shape, type, texture, and color of the fruit vary. The majority of seeds are endospermic. The chemical elements of the Solanaceae family include tropane alkaloids, scopolamine, atropine, hyoscyamine, and nicotine. Members of the Solanaceae family have medicinal and decorative properties. Poisoning and psychotropic activity is the most common symptom.

KEY WORDS: Solanaceae, Solanum, Hyoscyamine, Atropine

I. INTRODUCTION:

Family Solanaceae is one of the largest and economically most important families of angiosperms, including important food, spice and

drug plants. It belongs to the order of Solanales in the Astroid group of dicotyledons [Magnoliopsida]. It consists of about 98 genera and some 2700 species with great diversity of habitats, morphology and ecology. At least one species of Solanum is known as sunberry because its Solanaceous flowers resemble the sun and its rays. The name could originate from the Latin word solari, meaning soothe.^[1, 2, 3]

DISTRIBUTION:

The family has worldwide distribution, being present in all countries except Antarctica. The most diversity is found in South America and Central America. Most members are erect or climbing, annual, perennial herbs, but shrubs are not uncommon and there are few trees. 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 below. Solanum – the genus that typifies the family – includes nearly 50% of the total species of the Solanaceae.^[1, 4]

Table No.1- List of different Genera of Solanaceae Family with approximate no. of species:

Genera	Approximate number of species
Solanum	1330
Cestrum	150
Lycianthes	200
Nolana	89
Lycium	85
Physalis	85
Nicotiana	76
Brunfelsia	45
Estimated number of species in the family	2700

MORPHOLOGY:

Leaves: The leaves vary greatly in shape but are usually simple, pinnate or ternate although sometimes highly lobes. They are alternate, spiral and exstipulate. [3] 5, 6]

Table No. 2- Morphological comparison between *Physalis angulata* L, *Physalis minima* L., *Physalis peruviana* L. [6]

P.angulata L.	P.minima L.	P.peruviana L.
Leaf blade ovate- lanceolate, 4-5.5 1.5-2.5 cm, glabrescent, base oblique, wavy margins, apex acuminate	Leaf blade ovate or ovate lanceolate, 2-3 1- 1.5 cm, pubescent along veins, base cuneate, apex acuminate	Leaf blade cordate, 5-15 3-8 cm, pubescent, base cordate, apex acuminate



Fig.1) *P.angulata* L.



Fig.2) *P.minima* L.



Fig.3) *P.peruviana* L.

Flowers: Flower morphology influences which pollination can visit it and how efficient they are as pollen vectors. Inflorescence is generally cymose and axillary but may be reduced to single flower. These are bisexual, usually actinomorphic rarely zygomorphic and usually 5- merous.

The calyx is united, at least at the base, and sometimes becomes inflated in fruit. The corolla shape varies from long and tubular to rotate or campanulate but it is also in united. It is usually

actinomorphic, but there are some bilaterally symmetric genera. There are (5 rarely 4-8) epipetalous stamens that alternate with the corolla lobes. The anthers are never fused but sometimes they are touching with each other.

The gynoecium consists of single pistil, usually with 2 locules and numerous ovules. The fruit is a usually a berry but quite frequently a dry capsule. [6, 7, 3]

Table No. 3- Floral Formula:

⊕	Actinomorphic
♀	Bisexual
K(5)	Calyx – 5 sepals, gamosepalous (united)
C(5)	Corolla – 5 petals, gamopetalous

A5	Androecium – 5 stamens , polyandrous (free) ,epipetalous (attached to petals)
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•Morphological studies on *Brugmansia arborea* L,*Cestrum aurentiaceum*Lindl and *Capsicum frutescens* L.

***Brugmansia arborea* L.**

Flowers: Pedicelled, Bisexual, actinomorphic, hypogynous, white, pendulous. Calyx: 5 lobes, tubular, entire, acuminate, gamosepalous. Corolla: 5 lobes, tubular, funnel-shaped, very large pendulous, gamopetalous; twists aestivation.

Androecium: 5 Stamens, epipetalous, filaments filiform, anthers distinct, dehiscing longitudinally, inserted. Gynoecium: Bicarpellary, syncarpous, superior ovary; Ovary oblique in position. Many ovules in axial placentation.^[7]



Fig.4) *Brugmansia arborea* L.

***Cestrum aurentiacum* Lindl.**

Flowers: Pedicellate, Bisexual, hypogynous white small in size, actinomorphic. Calyx: 5, sepels; gamosepalous green. Corolla: 5,

petals, gamopetalous tubular, orange coloured. Androecium: 5, stamens, epipetalous, equal. Gynoecium: Bicarpellary, syncarpous, superior ovary with axile, placentation.^[7]



Fig.5) *Cestrum aurentiacum* Lindl

***Capsicum frutescens* L.**

Flowers: Pedicellate, Bisexual, hypogynous white small in size, actinomorphic. Calyx: 5 lobes, gamosepalous, cup shaped, embracing the base of fruit. Corolla: 5 lobes gamopetalous. Androecium:

stamens, epipetalous, filaments short, anthers about 0.4 cm long, dehiscing longitudinally. Gynoecium: Bicarpellary, syncarpous, superior ovary with axile placentation, ovary oriented in oblique manner. [7]



Fig.6) *Capsicum frutescens* L.

Axial (stem, wood) anatomy: Cork cambium is present in plant of Solanaceae family; initially superficial. Primary vascular tissue in a cylinder, without separate bundles; bicollateral. Internal phloem is present as strands or continuous ring.

Secondary thickening developing from a conventional cambial ring or anomalous.^[1]

Fruit morphology: The fruits are variable in shape, type, texture, color, size and dehiscence.^[8]

Table No.4- Fruit morphology of some species of Solanaceae family^[8]

Character	Species			
Name of plant	<i>Datura innoxia</i>	<i>Datura stamonium</i>	<i>Hyoscyamus Albus</i>	<i>Physalis angulate</i>
Fruit mean length /cm	3-3.9	3.2-4	1-1.3	1.2-1.5
Fruit mean width /cm	2.6-3.6	2.2-3	0.6-0.7	1.2-1.5
Fruit color	Brown	Brown	Brown	Yellowish green
Fruit type	Capsule	Capsule	Capsule	Berry
Fruit dehiscence	Valve	Valve	Circumscissile	Indehiscence
Fruit shape	Spherical	Ovoid	Oblong	Globose
Fruit calyx	Exposed	Exposed	Include in open calyx	Include in closed calyx
Fruit texture	Spiny	Spiny	Tuberculate	Glabrous



7) *Datura innoxia* 8) *Datura stramonium* 9) *Hyoscyamus albus* 10) *Physalis angulate*

Seed Morphology: Most of the seeds of Solanaceae family is endospermic. Endosperm oily or rarely starchy. Seeds not conspicuously hairy. Cotyledons 2; semi cylindric. Embryo may be straight or curved. ^[1, 8, 9]

Table No.5-Seed morphology of *D. stramonium*, *D. innoxia*, *Hyoscyamus albus*

	<i>Datura stramonium</i>	<i>Datura innoxia</i>	<i>Hyoscyamus albus</i>
Number of seeds in fruit	More than eight	More than eight	More than eight
Seed shape	Reniform	Reniform	Obovoid
Seed	Flattened	Convex	Slightly convex
Seed color	Light brown	Black	Yellowish brown
Seed texture	Rough	Rough	Tuberculate
Seed length(mm)	4.1-5	3.3-5	1-1.3
Seed width (mm)	3.3-5.4	2.3-2.8	1-1.1



Fig.11) *Datura innoxia*



Fig.12) *Datura stramonium*



Fig.13) *Hyoscyamus albus*

MICROSCOPY:

Root: Table No. 6- Microscopy of root of *Solanum macrocarpum* and *Solanum nigrum*^[10]

Characters	<i>S. macrocarpum</i>	<i>S. nigrum</i>
Nature of the endodermis	Not clearly differentiated	Not clearly differentiated
Epidermal cells	Big and well differentiated	Small and well differentiated
Shape of epidermal cells	Pentagonal to hexagonal	Irregular
Cells outside the cortex	Thick, big and 4-5 layers	Thin, small and elongated
Size and number of vascular bundles	Small and few	Small and few
Size and number of vessels	Small and many	Small and many
Oxalate crystals	absent	Present



Fig.14) Transverse section of root of *Solanum macrocarpum* Fig.15) Transverse section of *Solanum nigrum*

CHEMISTRY : Solanaceae are known for having a diverse range of alkaloids. Alkaloids are nitrogenous organic substance produced by plants as secondary metabolite and which have an intense physiological action on animals at low doses. To humans, these alkaloids can be toxic, desirable or both.

It contains more quantity of tropane alkaloids are found. The plant which contains tropane alkaloids have been used for centuries as poisons. Scopolamine, atropine, hyoscyamine, and nicotine are the species which contain variety of alkaloids that can be more or less active or poisonous.^[1]

•The toxic solanaceous compounds are:

1) Tropane alkaloids: Genera: *Atropa*; *Datura*; *Hyoscyamus*; *Mondragora*.

- 2) Pyrrolidine and pyrrolic alkaloids: Genera: *Nierembergia* (examples, *N. hippomanica*); *Physalis* spp; *Solanum* (example, *S. sturtianum*)
- 3) Protoalkaloids: Phenethylamines: Genus: *Nierembergia*.
- 4) Glycoalkaloids: Genera: *Lycopersicon*; *Solanum*.
- 5) Nicotine: Genus: *Nicotiana* (example, *N. tabacum*)
- 6) Cardenolides: Genera *Cestrum* (example, *C.parqui*); *nierembergia* (example, *N. aristata*)
- 7) Capsaicinoids: Genus: *Capsicum*.
- 8) Kaurene-type tetracyclic diterpenes: Genus *Cestrum* (example, *C.parqui*)

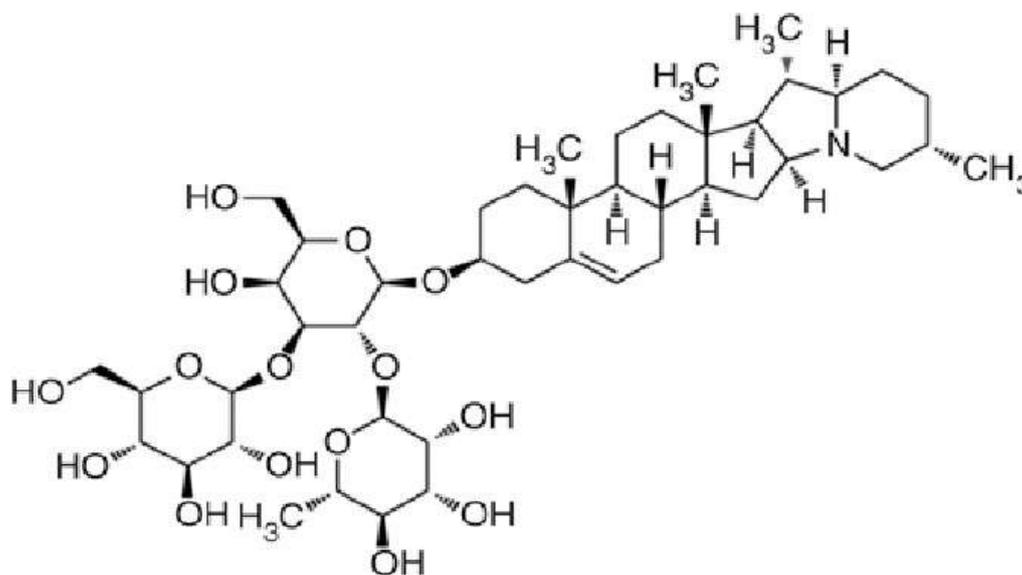
- 9) Steroidal glycosides (neutral saponins):
Genera: Cestrum (example, C. parqui); Solanum (example, S. nigrum)
- 10) 1,25-Dihydroxyvitamin D3 and vitamin D3:
Genera: Cestrum (example, C. diurnum); Nierembergia (example, N. Veitchii)
- 11) Withasteroids: A) Withanolides: Genus: Withania. B) Physalins: Genus: Physalis.
- 12) Other bioactive chemical constituents: A) Sugar esters. B) Lectins^[11]

Some of the main types of alkaloids are:

Solanine: A toxic glycoalkaloid with bitter taste, it has the formula $C_{45}H_{73}NO_{15}$. It is green colored pigmented glycoalkaloid and acts as natural pesticide, also known as alpha solanine. The plants of these family has alpha solanine is naturally

produced and the other plants such as potatoes, tomatoes, apples, bell peppers, cherries, and sugar beets. Higher concentration of solanine is present in areal and green part of the plant. [31]

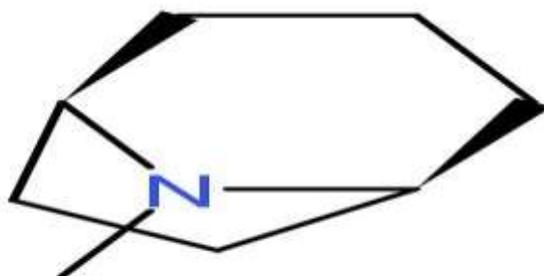
Its production is thought to be an adaptive defence strategy against herbivores. Substance intoxication from solanine is characterized by gastrointestinal disorders like abdominal pain diarrhea, vomiting and neurological disorders headaches and hallucinations. After 8 to 12 hrs symptoms become manifest when it is injected. Berries from species such as Solanum nigrum or Solanum dulcamara, or green potatoes are responsible for poisoning in people due to Solanine. The median lethal dose is between 2 and 5 mg per kg of body weight. The average glycoalkaloid concentration is 0.07 5mg/g of potato.^[12]



Structure of Solanine

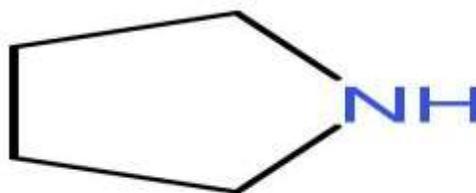
Tropanes: Tropane alkaloids has a chemical formula $C_8H_{15}N$ which contains bicyclic organic nitrogen compound. These alkaloids include atropine, cocaine, scopolamine, and hyoscyamine. The term “tropane” comes from a genus in which they are found, *Atropa* (the belladonna genus). *Atropa* is named after the Greek Fate, *Atropos*, who cut the thread of life. This nomenclature reflects its toxicity and lethality. *Hyoscyamus muticus* and *Scopolia atropioides* contain scopolamine which is used as an antiemetic against motion sickness or for people suffering from nausea as a result of receiving chemotherapy. Tropane alkaloids such as scopolamine and hyoscyamine are the most widely used in pharmacology and medicine due to their effects on the parasympathetic nervous system. Scopolamine has a sedative effect, whereas atropine has a stimulant effect on central nervous system and heart. These alkaloids cannot be substituted by any other class of compounds, so they are still in demand. Pharmacologically, they are most powerful known anticholinergic in existence, meaning they inhibit the neurological singles

transmitted by the endogenous neurotransmitter, acetylcholine. Atropine dilates pupil so that they are commonly used as ophthalmological agents. Due to extreme toxicity of tropanes, they are useful drugs when administered in extremely in small dosages. Like atropine, and hyoscyamine, scopolamine is an anticholinergic agent that in low doses blocks the cholinergic receptors of the brain, depressing the impulses of the nervous terminals, while in high doses, these compounds cause stimulation before depression. Scopolamine causes convulsions, severe depression, heart arrhythmias, severe tachycardia, fibrillation, breathing disturbances, vascular collapse, and death if the dose is given more than 10 mg in children and more than 100mg in adults. The maximum effect is reached after 1 to 2 hours and then it diminishes very slowly. It is still widely used as anaesthetic practice and in other medicinal field. Tropane alkaloids are chemical plant defenses. The tropane alkaloids should be avoided in glaucoma, prostatic hypertrophy, and patients with urinary tract diseases and also during pregnancy. [1, 11, 12]



Structure of Tropane

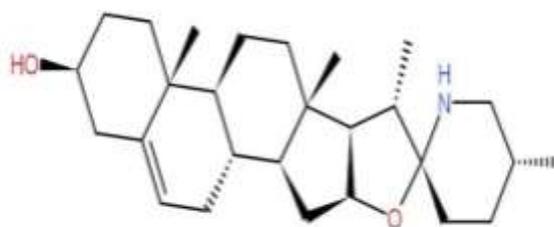
Pyrrolidine and pyrrolic alkaloids: In Solanaceous plants, for example, hygrine and anaferine and other *Physalis* species, pyrrolidine alkaloids are found. The methyl ester of homohygrinic acid in *Solanum sturtianum*, and N-methylpyrrolidinylygrines A and B in *Datura innoxia*.^[1]



Structure of Pyrrolidine

Solasodine: Solasodine has molecular formula $C_{27}H_{43}NO_2$. Solanaceous family rich in steroidal glycoalkaloids, which is an important group of plant secondary metabolites. In the synthesis of steroidal drugs these compounds are used as starting material. In majority of Solanaceous plants, solasodine occurs as aglycone part of glycoalkaloids, which is a nitrogen analogue of sapogenine. It contains glycoalkaloids such as solamargine and solasonine. Solasodine has C27 cholestane skeleton. It can be readily converted to 16-dehydropregnenolone, which is key intermediate in the synthesis of steroidal drugs such as progesterone and cortisone. Solasodine is obtained by chemical or microbial hydrolysis of solamargine and it is potent moiety to be used as a substitute for diosgenin in the semisynthetic

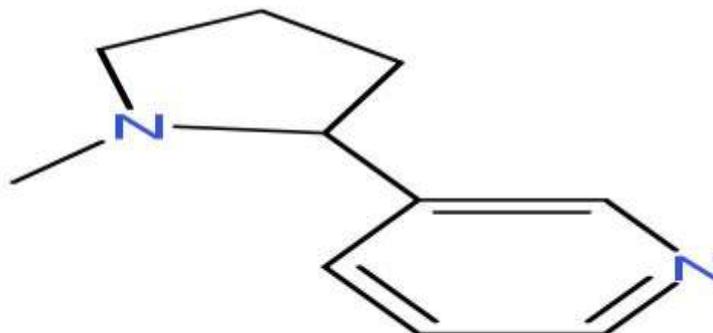
production of steroidal hormones in pharmaceuticals. Therefore, steroidal glycoalkaloid from solanaceae plants become increasingly important as the starting material for the production of steroidal hormones, which may penetrate, by simple diffusion, the placental barrier and the blood brain barrier and impact the fetuses. Solasodine, and methanol extract of *S. trilobatum* also showed significant antiinflammatory activity. Solasodine glycosides are also clinically and histologically effective in the treatment of skin tumors. Solasodine which is isolated from *S. sisymbriifolium* shows anticonvulsant and CNS depressant effect. The results showed that in the PCT-induced convulsions intraperitoneal injections of solasodine significantly delayed latency of hind limb tonic extensor phase.^[11, 12, 13]



Structure of Solasodine

Nicotine: Nicotine is natural alkaloid, mainly found in the tobacco plant (*Nicotiana*) which belongs to the Solanaceous family. Nicotine has chemical formula $C_{10}H_{14}N_2$. Nicotine has IUPAC nomenclature is (S)-3-(1methylpyrrolidine-2-yl)pyridine). It is pyrrolidine alkaloid. Lower concentration of nicotine is present in potato, tomato, and pepper. Its function in plant is to act as a defence against herbivores, as it is an excellent neurotoxin, in particular against insecticides. Nicotine acts as a stimulant in mammals at a low

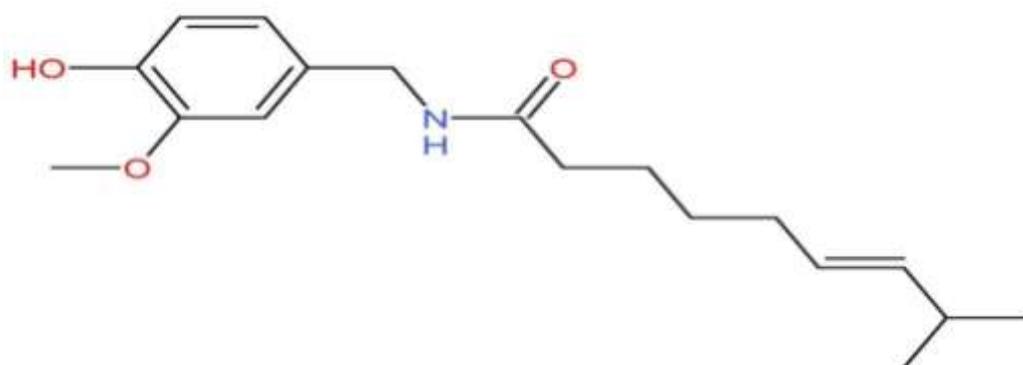
concentrations, which causes the dependency in smokers. It acts on cholinergic neurons, but with the opposite effect. Nicotine is very toxic in high dose concentration. The lethal dose in man is 50-100 mg, which approximately corresponds to the nicotine content of tobacco in 5 cigarettes. At lower doses it has many pharmacological effects. Nicotine has a higher specificity for nicotinic acetylcholinergic receptors than other Ach proteins.^[1, 14, 15]



Structure of Nicotine

Capsaicin: Capsaicin, derived from the plants of the genus *Capsicum*, belongs to the Solanaceae family. Capsaicin is non polar phenolic structure, and therefore it is insoluble in water. Nonpolar solvents like ether, benzene, dimethyl sulfoxide, and acetone are used to extract and maintain capsaicin properties. The IUPAC nomenclature for capsaicin is the 8-methyl-N-vanillyl-trans-6-nonenamide. Capsaicin, has the pungent flavour. It is found in species of genus *Capsicum*, which includes peppers or chillies and habaneros and it is the active ingredient that determines the scoville rating of these species. Capsaicin is not toxic compound to the human being. It stimulates specific pain receptors in the majority of mammals.

It affects only mammals, not birds. Capsicum extract and capsaicin modulate T cell immune responses, and their immunomodulatory effects on murine Peyer's patch cells are partly due to both transient receptor potential vanilloid 1 (TRPV1) dependent and independent pathways. Capsaicin plays a vital role as an agonist for the TRPV1 (transient receptor potential cation channel, subfamily V, member 1) receptor. Capsaicin is used as medication and as tear gas. Capsaicin is used in urology for the treatment of dysfunctions, like vesicle hyperactivity, detrusor hyperreflexia and vesicle pain.^[1,11], [16]



Structure of Capsaicin

Table No. 7) Medicinal plants of Solanaceae family:

GENUS	SPECIES	COMMON NAME	PART USED	CHEMICAL CONSTITUENT	USES
Atropa	Atropa belladonna	Deadly nightshade divale, banewort, devil' berries, death cherries, beautiful death, devil's herb[18]	Root[18]	Hyoscyamine, atropine, starch, atrosine, scopolamine[17,18]	1. Antidote to opium and stimulates to the sympathetic nervous system. 2. It is used in treatment of headache, menstrual symptoms, Peptic ulcer disease. 3.It shows anticholinergic activity.[17, 18, 19, 20]

Withania	Withania	Winter	Whole	Alkaloids contain	1. Used in
	somniferadunal	cherry, Indian ginseng, ashwagandha[21]	plant, roots, leaves, stem, green berries, fruits, seeds, bark[21]	ashwagandhine, anahygrine, cusohygrine, tropine. Steroidal compounds include ergostane type steroidallactones, withaferin A,withasomniferi n-A, withanone [21.23]	ayurvedic system as aphrodisiac, diuretics and for memory loss. 2. It shows antioxidant, anticonvulsant and sedative effect. 3. Its leaves are used in Ayurvedic and Unani systems for treatment of tumors and tubercular glands [21, 22, 23, 24]
Hyoscyamus	Hyoscyamus niger	Henbane, black henbane, stinking nightshade [25]	Leaves, root seed[27]	Tropane alkaloids mainly hyoscyamine and scopolamine. Hyoscyamine-N-oxide, skimmianine, hyoscine, tropine, belladonines, apohyoscine, apotropine, atropine, (-)-6hydroxyhyoscyamine, hyoscyamide, 1,24tetracosanediol diferulate, cannabisin D, cannabisin G. non alkaloids constituents such as withanolide steroids, steroidal saponins, glycosides, coumarinolignan and flavonoids.[25.27]	1. Used as sedative and pain killer 2. Shows narcotic, anti-inflammatory, anthelmintic, stomachic, cardotonic, expectorant, haemostatic, anti-spasmodic, mydriatic effect. 3. It is used in worm infection, colic, dyspepsia, rheumatoid arthritis, whooping cough, asthma, bronchitis.[25, 26, 27]

Datura	Datura stromonium	Thorn apple, stinkweed, angels trumpet, Jamestown weed[28]	Whole plant[28]	Major component is the tropane alkaloids hyoscyamine. Minor alkaloids are atropine, scopolamine, apoatropin, hyoscyamine N-oxide and scopolamine N-oxide. 3-phenylacetoxy-6,7-epoxynortropane and 7-	<ol style="list-style-type: none"> Useful in treatment for the central cholinergic symptoms of organophosphate poisoning. It has bactericidal activity against gram positive bacteria It shows antihelmintic, antiparasitic, analgesic and
				hydroxyapoatropine are newly found tropane alkaloids. the other chemical constituents are N-trans-feruloyl tryptamine, hyoscyamilactol. ^[28,30]	Anti-inflammatory effect. Used in treatment of parkinsonism and hemorrhoids. ^[28,29,30,31,32]
Capsicum	Capsicum annum	Chili pepper, sweet pepper, Christmas pepper, red pepper, ornamental chilli pepper	Fruits and leaves[1]	Capsaicin, capsanthin, carotene, thiamine and ascorbic acid ^[1]	1. Used as stomachic, appetizer, carminative, counter irritant the treatment of rheumatism, lumbago and neuralgia [1, 33]



Fig.16) Atropa belladonna



Fig.17) Withania somnifera



Fig. 18) *Datura stramonium*



Fig.19) *Hyoscyamus niger*



Fig.20) *Capsicum annum*

II. CONCLUSION:

The study concludes that the plants which come under Solanaceae family show diuretic, sedative, antispasmodic, narcotic, anti-asthmatic, anticholinergic pharmacological action. Hyoscyamine, atropine, scopolamine and tropane alkaloids are the main chemical constituents. Tropane alkaloids such as scopolamine and hyoscyamine are the most widely used in pharmacology and medicine due to their effects on the parasympathetic nervous system. Capsaicin is used in urology for the treatment of dysfunction, like vesicle hyperactivity and vesicle pain. Study shows that at higher dose of Solanaceae family herbs shows toxic effect.

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