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Pharmacological properties of *Datura stramonium* L. as a potential medicinal tree: An overview

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PEER REVIEW

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Comments

From the time of immemorial, plants have been widely used as curative agents for variety of ailments. Present review gives a broad information about the bioactive constituents, ethnopharmacology along with the scientifically claimed medicinal uses of *Datura stramonium*. The contents of this paper are highly beneficial to scientists who want to work on this plant.

(Details on Page 1007)

ABSTRACT

India has a great wealth of various naturally occurring plant drugs which have great potential pharmacological activities. *Datura stramonium* (*D. stramonium*) is one of the widely well known folklore medicinal herbs. The troublesome weed, *D. stramonium* is a plant with both poisonous and medicinal properties and has been proven to have great pharmacological potential with a great utility and usage in folklore medicine. *D. stromonium* has been scientifically proven to contain alkaloids, tannins, carbohydrates and proteins. This plant has contributed various pharmacological actions in the scientific field of Indian systems of medicines like analgesic and antiasthmatic activities. The present paper presents an exclusive review work on the ethnomedical, phytochemical, pharmacological activities of this plant.

KEYWORDS

Datura stramonium, Jimsonweed, Phytochemistry, Ethnopharmacology, Traditional uses, Pharmacology

1. Introduction

Plants have always played a major role in the treatment of human traumas and diseases worldwide. The demand for medicinal plant is increasing in both developed and developing countries due to growing recognition of natural product. Herbal medicine is an important part of both traditional and modern system of medicines[1]. *Datura stramonium* (*D. stramonium*) is a widespread annual plant from the Solanaceae family. It is one of the widely well known folklore medicinal herb. It is a wild growing flowering plant and was investigated as a local source for tropane alkaloids which contain a methylated nitrogen atom ($N-CH_3$) and include the anti-cholinergic drugs atropine, and scopolamine. From ancient civilization it was traditionally used for religious visionary purposes throughout the world and used by witchcraft in medieval Europe. The god lord Shiva was known to smoke *Cannabis* and *Datura*. People still provide the small thorn apple during festivals and special days as offerings in Shiva

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icons at temples. An extract made from the leaves is taken orally for the treatment of asthma and sinus infections, and stripped bark are applied externally to treat swellings, burns and ulcers. The incidence of *D. stramonium* poisoning is sporadic with a cluster of poisoning cases in the 1990s and 2000s, the United States media reported some cases occurring mostly among adolescents and young adults dying or becoming seriously ill from ingesting. Some medicinal uses of the plant are its anti-inflammatory property of all parts of the plant, stimulation of the central nervous system, respiratory decongestion, treatment of dental and skin infections, alopecia and in the treatment of toothache. It is a hallucinogenic plant that causes serious poisoning. Consumption of any part of the plant may result in a severe anticholinergic reaction that may lead to toxicity and occasionally cause diagnostic difficulties. Cases of poisoning have been reported after eating the berries. Death may occur from heart failure after ingesting 125 seeds, because the seeds contain the highest concentration and has a rapid onset of action, thus may be potentially useful as an alternative to atropine for the treatment of the muscarinic symptoms of organophosphate toxicity and some of central anticholinergic effects. The wide distribution, the strong toxicity and the potential for occurrence in foodstuffs are responsible for the numerous incidents in humans[2]. *Datura* genus distributes over tropical and warm temperate regions of the world. About ten species of *Datura* are found, of which *Datura anoxia* and *D. stromonium* are most important drug plants. *Datura* has long been known as a medicinal plant and as a plant hallucinogen all over the world. Pre-historic use of *Datura* in medicinal and ceremonial rituals could be observed in aboriginal in Indian sub-continent[3]. The therapeutic activities of most plants are due to the presence of one or more of such components like alkaloids, tannins, saponins and cardiac glycosides. The phytochemical screening revealed the presence of saponins, tannins, steroids, alkaloids, flavonoids, phenols and glycosides[4].Atropine and scopolamine are competitive antagonists of muscarinic cholinergic receptors and are central nervous system depressants. All parts of the plant are toxic, but the highest amount of alkaloids is contained in the ripe seeds[4,5]. Many cases of accidental poisoning by *D. stramonium* have been reported when these plants were eaten accidentally[6].

2. Regional and other names

Sanskrit:	Umatta-virkshaha
English:	Thornapple
Hindi:	Sadah-*Datura*, Safed *Datura*
Tamil:	Umatai
Arab:	Jonz-masal
Gujrat:	Dhatoria
Bengali:	Dhattura
Malayalam:	Maraummam
Marathi:	Kanaka

3. Scientific classification of *D. stromonium*

Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Solanales
Family:	Solanaceae
Genus:	*Datura*
Species:	*Datura stromonium*

4. Botanical description

4.1. Plant appearance

D. stramonium is an annual plant (Figure 1). The stem is herbaceous, branched and glabrous or only lightly hairy. By cultivation the plant reaches a height of about one meter[7,8]. The branching stems are spreading, leafy, stout, erect, smooth and pale yellowish green in color, branching repeatedly in a forked manner. Leaves are hairy, big, simple dentate, oval glabrous, apposite veins of leaves are pale black, stalked, 4-6 inch long, ovate and pale green. The upper surface is dark and grayish-green, generally smooth, the under surface paler, and when dried, minutely wrinkled (Figure 1a). *D. stramonium* bears funnel shaped, white or purple coloured flowers, with 5 stamens and superior ovary (Figure 1b). The average length of flower is about 3 inches. The calyx is long, tubular and somewhat a swollen below and very sharply five angled surmounted by five sharp teeth. Corolla is funnel shaped. Stem stalk is pale blue or greenish white. Seeds

Figure 1. *Datura stramonium*.
a: *Datura* plant (leaves and flowers); b: *D. stramonium* fruit; c: *D. stramonium* flower.

are black, kidney shape and flat[9,10]. Fruits are as large as walnuts and full of thorns (hence the English name "thorn apple") (Figure 1c). The plant is strong narcotic, but has a peculiar action on the human which renders it very valuable as medicines. The whole plant is poisonous and the seeds are the most active; neither dying nor boiling destroys the poisonous properties. The symptoms of acute Jimsonweed poisoning included dryness of the mouth and extreme thirst, dryness of the skin, pupil dilate ion, impaired vision, urinary retention, rapid heartbeat, confusion, restlessness, hallucinations, and loss of consciousness[2].

4.2. Distributions

D. stromonium is probably originated in Caspian Sea territories and spreaded to Europe in the first century. At present it grows in waste places in Europe, Asia, America and South Africa. *D. stromonium* is cultivated in Germany, France, Hungary, South America and throughout the world[8].

4.3. Cultivation and collection

Thorn apple is easily cultivated, growing well in open, sunny situation. It flourishes in most moderately good soil but grows best in calcareous rich soil, or in a good sandy loam, with leaf mould added. Seeds are sown in open in May, in drill 3 feet apart, barely covered. Sown thinly, as the plants attain a good size and grow freely from seed. Thin out the young plants to a distance of 12 to 15 inches between each plant in the drill. The soil should be kept free from weeds in the early stages. If the summer is hot and dry, give a mulching of rotted cow-manure. If grown for leaf crop, the capsule should be picked off as soon as formed, as in a wind the spines tear the leaves. In August the plant reaches to a hight of 1 meter and bears flowers and fruits. In the end of August stems with leaves and flowering tops are collected and dried as soon as possible at 45 ℃ to 50 ℃. The leaves should be gathered when the plant is in full bloom and carefully dried. They are generally harvested in late summer. In August, the crop is cut by the sickle on a fine day in the morning, after the sun has dried off the dew, and the leaves are stripped from the stem, dried carefully as quickly as possible[8-10].

5. Ethanomedical uses

Plant derived drugs come into use in the modern medicine through the uses of plant material as indigenous cure in folklore or traditional systems of medicine. The leaves of *D. stromonium* L. are used for the relief of headache and vapours of leaf infusion is used to relive the pain of rheumatism and gout. The smoke from the burning leaf is inhaled for the relief of asthma and bronchitis. European remedy of *D. stromonium* for haemorrhoid is to steam the part over boiling water containing leaf. The fruit juice is applied to the scalp for the treatment of falling hair and dandruff. It is also applied to smooth painful wounds and sores. Seeds and leaves of *D. stromonium* were used to sedate hysterical and psychotic patients, also to treat insomnia[11]. *D. stromonium* was used as hallucinogenic drug. It is also used to relax the smooth muscles of the bronchial tube and asthmatic bronchial spasm. It was reported that *D. stromonium* was used internally to treat madness, epilepsy and depression. Externally it forms the basis of ointment for burns and rheumatism[12]. It is also used in the treatment of parkinsonism and hemorrhoids. Its leaves, applied after roasting, are useful in relieving pain. The bitter narcotic plant relieves pain and encourages the healing process. The seeds of the plant are medicinally the most active. Externally, the plant is used as a poultice in treating fistulas, abscesses wounds and severe neuralgia. Scopolamine is also found in the plant, which makes it a potent cholinergic-blocki hallucinogen that has been used to calm schizoid patients. Its leaves, containing hyoscyamine and atropine, can be used as an immensely powerful mind-altering drug. The seeds of *Datura* are analgesic, anthelmintic and anti-inflammatory and as such, they are used in the treatment of stomach and intestinal pain that results from worm infestation, toothache, and fever from inflammation. The juice of its fruit is applied to the scalp, to treat dandruff and falling hair. The growing plant works as an insect repellant, which protects neighboring plants from insects[2]. *D. stromonium* is mostly used as anthelmintics and antiparasitic in Marche, Abruzzo and Latium. Records of continued use of the plant in these sectors was collected from farmers and shepherds (mostly old people)[4,13].

6. Phytochemicals

The major tropane alkaloids hyoscyamine and scopolamine and several minor tropane alkaloids have been identified in *Datura* species. Typical examples of minor alkaloids in *D. stramonium* are tigloidin, aposcopolamine, apoatropin, hyoscyamine N-oxide and scopolamine N-oxide17-20. 6 â-ditigloyloxytropane and 7-hydroxyhyoscyamine are reported for the first time in this species[2].

Distribution of hyoscyamine and scopolamine in *D. stromonium* was studied. The production of hycyamine and scopolamine in *D. stromonium* has been investigated in the different plant parts, at different stages of their life cycle. The maximum contents were found in the stems and leaves of young plants, hyocyamine being always the predominate component. These compounds were included in many pharmacopieas because of their anticholinergic activities[4].

D. stromonium contain variety of alkaloids including atropine, hyoscamine and scopolamine[14].

Sixty-four tropane alkaloids have been detected from *D. stramonium*. Two new tropane alkaloids, 3-phenylacetoxy-6, 7-epoxynortropane and 7-hydroxyapoatropine were tentatively identified. The alkaloids scopoline, 3-(hydroxyacetoxy) tropane,

3-hydroxy-6-(2-methylbutyryloxy) tropane, 3â-tigloyloxy-6-hydroxytropane, 3, 7-dihydroxy-6-tigloyloxytropane, 3-tigloyloxy-6-propionyloxytropane, 3 phenylacetoxy-6,7-epoxytropane, 3-phenylacetoxy-6-hydroxytropane, aponor scopolamine, 3â, 6â-ditigloyloxytropane and 7-hydroxyhyoscyamine are reported for the first time for this species. Other alkaloids found in *D. stramonium* include[15]: Hygrine, 3á, 6â-Ditigloyloxy-7-hydroxytropane, 6-Hydroxyhyoscyamine, Pseudotropine, 3á-Tigloyloxytropane, Hydroxy-6-tigloyloxytropane, Phenylacetoxytropane, 3-Tigloyloxy-6-(2-methylbutyryloxy) tropane, Hyoscyamine, 3-Tigloyloxy-6-isovaleroyloxy-7-hydroxytropane, Scopolamine, Tropinone, Scopine, 6-Hydroxyacetoxytropane, 3,6-Diacetoxytropane, 3-Tigloxyloxy-6-acetoxytropane, 3-Tigloyloxy-2-methylbutyryloxytropane, 3á, 6â-Ditiglotoxytropane, 3-Acetoxy-6-isobutyryloxytropan, 3-(2-Phenylpropionyloxy) tropane, Littorine, 6-Hydroxyapoatropine, 3â, 6â-Ditigloyloxy-7-hydroxytropane, 3-Tropoyloxy-6-acetoxytropane, 3,6-Dihydroxytropane, 3â-Tigloyloxytropane, 3-Tigloyloxy-6-propionyloxy-7- hydroxytropane, 3á-Apotropoyloxytropane, Aposcopolamine, 3â, 6â-Ditigloyloxytropane, 3-(3′-Acetoxytropoyloxy) tropane, 3á-Tigloyloxy-6-hydroxytropane, Tropine, 3-Acetoxytropane, 3-Hydroxy-6-acetoxytropane, 3-Hydroxy-6-methylbutyryloxytropane, 3-Tigloloxy-6-isobutyryloxytropane, Aponorscopolamine, 7-Hydroxyhyoscyamine, Meteloidine, 3â, 6â-Ditigloyloxytropane.

The phytochemical analysis of the plant revealed that *D. stramonium* contained saponins, tannins and alkaloids and glycosides. The secondary metabolites identified in the plant materials in the study of Banso A and Adeyemo S showed antimicrobial activity[16].

7. Pharmacological activity

7.1. Antiasthmatic activity

D. stromonium in asthma treatment and possible effects on prenatal development was studied. Exposure of the foetus to *D. stromonium* when a mother use it for asthma, will cause a continuous release of acetylcholine, resulting in the desensitization of nicotinic receptors, this could ultimately result in permanent damage to the foetus. Therefore we conclude that this African herbal remedy should be used with caution during pregnancy[17].

7.2. Anticholinergic activity

The alkaloids found in *D. stramonium*, are organic esters used clinically as anticholinergic agents. Jimson weed has been reported as a drug of abuse and has been involved in the accidental poisoning of humans and animals. Symptoms of acute jimson weed poisoning included dryness of the mouth and extreme thirst, dryness of the skin, pupil dilation and impaired vision, urinary retention, rapid heartbeat, confusion, restlessness, hallucinations, and loss of consciousness. The anticholinergic syndrome results from the inhibition of central and peripheral muscarinic neurotransmission[18-20].

7.3. Acaricidal, repellent and oviposition deterrent properties

The ethanol extracts obtained from both leaf and seed in *D. stromonium* (Solanaceae) were investigated for acaricidal, repellent and oviposition deterrent properties against adult two-spotted spider mites (*T. urticae* Koch) (Acari: Tetranychidae) under laboratory conditions. Leaf and seed extracts, which were applied in 167.25 and 145.75 g/L concentrations, respectively (using a Petri leaf disc-spray tower method), caused 98% and 25% mortality among spider mite adults after 48 h. These results suggest that *D. stramonium* extracts could be used to manage the two-spotted spider mite[21].

7.4. Antimicrobial Activity

The methanol extracts of *D. stromonium* and *Datura inoxia* showed activity against Gram positive bacteria in a dose dependent manner. Little or no antimicrobial activity was found against *Escherichia coli* and *Psuedomonas aeruginosa*[22]. The anti-microbial activity of combined crude ethanolic extract of *D. stromonium*, *Terminalia arjuna* and *Withania somnifera* in cup plate diffusion method for antibacterial and antifungal activity. The extracts were subjected to screening to detect potential antimicrobial activity against *Staphylococcus aureus*, *Bacillus subtilus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Micrococcus luteus* and *Candida albicans* with compare Ciprofloxacin standard drug[23].

7.5. Anticancer activity

An integrated approach is needed to manage cancer using the growing body of knowledge gained through scientific developments. Thousands of herbal and traditional compounds are being screened worldwide to validate their use as anti-cancerous drugs. *D. stromonium* in therapeutic dose of 0.05-0.10 g was used to cure cancer. Likely unsafeproduce vomiting, hypertension, loss of consciousness may lead to coma but may interact with anti-cholinergic drugs[24].

7.6. Antiinflamatory activity

Coriandrum sativum (*C. sativum*), *D. stromonium* and *Azadirachta indica* (*A. indica*) are traditionally used in treatment of inflammation. Ethanolic extracts of fruits of *C. sativum*, leaves of *D. stromonium*. Ethanolic extracts of fruits of *C. sativum*, leaves of *D. stromonium* and *A. indica* were subjected to preliminary screening for anti-inflammatory activity in albino rats. All ethanolic extracts exhibited significant anti-inflammatory activity comparable to the standard drug diclofenac sodium against carrageenan induced rat paw edema method. Among these plant *A. indica* showed maximum anti-inflammatory activity per hour[25].

7.7. Larvicidal and mosquito repellent activities

Ethanolic extracts of leaves of *D. stromonium* were evaluated for larvicidal and mosquito repellent activities against *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus*. The LD_{50} values for larvicidal activity were found to be 86.25, 16.07 and 6.25 mg/L against *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus* respectively. The ethanolic leaves extract of *D. stromonium* provided complete protection time (mosquito repellency) of 2.7, 71.7 and 117.7 min against *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus* at higher concentration (1%)[26].

7.8. Pesticide toxicity

Extract of *D. stromonium* was effective in countering the toxicity of the cypermethrin pesticide toxicity[27].

7.9. Antifungal activity

Antifungal activity of a concoction brewed from *D. stromonium*, *Calotropis gigantea*, *A. indica* (neem) and cow manure (T1) followed by methanol-water (70/30 v/v) extracts of *D. stromonium*, *Calotropis gigantea* and *A. indica* T2 against *Fusarium mangiferae*. The study proved that the concoction-brewed compost T1 is effective, inexpensive, easy to prepare and constitutes a sustainable and eco-friendly approach to control floral malformation in mango when it is sprayed at bud break stage and again at fruit set stage[28].

7.10. Vibriocidal activity

A simple *in vitro* screening assay was employed for the standard strain of *Vibrio cholerae*, 12 isolates of *Vibrio cholerae* non-O1, and *Vibrio parahaemolyticus*. Aqueous and organic solvent extracts of different parts of the plants were investigated by using the disk diffusion method. Extracts from 16 medicinal plants were selected on account of the reported traditional uses for the treatment of cholera and gastrointestinal diseases, and they were assayed for vibriocidal activitie. The results indicated that *Lawsonia inermis*, *Saraca indica*, *Syzygium cumini*, *Terminalia belerica*, *Allium sativum*, and *D. stromonium* served as broad-spectrum vibriocidal agents[39].

7.11. Toxicity studies

Toxicity studies of ethanol extract of the leaves of *D. stromonium* in rats. Two doses of 50 and 200 mg/kg of the extract were administered to the rats for five weeks. Parameters studied were the indices of liver and kidney function and some biochemical and haematological parameters. Feed intake, final body weight, serum AST, ALT, billurubin, total protein, urea and the electrolyte studied were not affected by the extract administration. Serum creatinine levels were however significantly raised in the rats administered with ethanol extract at the dose of 200 mg/kg body weight. The biochemical and haematological parameters were also affected[30]. The effects of acute, subacute and chronic administration of alkaloids atropine and scopolamine, the main constituents of the active principle of *D. stromonium*, with toxic properties, were studied in male Albino Wistar rats. After acute *i.p.* administration of dose 100 mg/kg of total alkaloids to the seeds of *D. stramonium*, there were no remarkable changes in general appearance and no deaths occurred in any experimental group. Twenty four hour after total alkaloids of seeds, a significant reduction in indices of liver, spleen brain and kidney function and some biochemical and haematological parameters were observed. The red blood cells, hematocrit, hemoglobin and white blood cells were significantly higher in the treated groups than the control group. Subacute study for four weeks showed no resulting mortality or signs of toxicity. In chronic study, the synthetic alkaloids administered *i.p.* at daily doses of 4.2 mg/kg of atropine and 1.6 mg/kg of scopolamine, did not produce death. However diarrhoea and hypoactivity were observed. The relative weight of liver was significantly less than that of the control group[31].

7.12.Biopesticide with antifungal activity

Biopesticides (leaf extracts) obtained from eight plants (*Vitex negundo*, *Polyathia longifolia*, *Vinca rosea*, *Withania somnifera*, *Lawsonia inermis*, *Adhotoda zylanica*, *D. stromonium and Hyptis suaveolens*) showed antifungal activities against the fungal pathogen (*Fusarium oxysporum*) of wilt of pigeon pea (*Cajanus cajan* L.). Both *in vivo* and *in vitro* higher concentration of ethanotic leaf extracts of all eight plants showed complete inhibition in linear growth and sporulation in test fungi[32].

7.13. Protective agent in severe organophosphate toxicity

Treatment of patients following an organophosphate (OP) exposure can deplete a hospital's entire supply of atropine. Given the possibility of multiple severe exposures after a terrorist attack using OP nerve agents, there exists a need for either greater atropine stores or the development of alternative antidotes. Jimsonweed (*D. stromonium*) contains atropine and other anticholinergic compounds and is common and readily available. It is used recreationally for its central anticholinergic effects and is easy to be made into an extract by boiling the crushed seeds. The extract has rapid onset of effects and may be useful for treatment of OP poisoning. Pretreatment with *D. stromonium* extracts significantly increases survival following severe dichlorvos exposure[33].

8. Safety aspect

Careful consideration of the toxicity of the plant is required before its use. Its ingestion induces characteristic symptoms. The mouth becomes dry, an intense thirst develops, the vision gets blurred with prominent mydriasis and the heart rate increases. This is followed by hallucinations, delirium, and loss of motor coordination which may lead to command ultimately to death by respiratory failure[34].

9. Quantitative standards

Dosage: 50-100 mg of dried leaf or the same amount in infusion.
Total ash: Not more than 20.0%.
Total alkaloid: Not less than 0.05% calculated as hyoscyamine.
Foreign matter: Not more than 3.0% of stem having a diameter exceeding 5 mm.
Acid insoluble ash: Not more than 4.0%.

10. Conclusion

Present review gives a broad information about the bioactive constituents, ethnopharmacology along with the scientifically claimed medicinal uses of *D. stramonium*. Several alkaloids, carbohydrates, fat, proteins and tannins have been reported to be present in different parts of *D. stramonium*. The plant shows various types of activities such as analgesic and antiasthamatic activity which may be due to the presence of the investigated active chemical constituents. The pharmacological studies so far have been performed *in vitro* and *in vivo*. Therefore, there is a need of investigation and quantification of phytoconstituents and pharmacological profile.

Conflict of interest statement

We declare that we have no conflict of interest.

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Comments

Background

D. stramonium Linn is one of the widely well known folklore medicinal herb. *D. stramonium* is a plant with both poisonous and medicinal properties and has been proven to have great pharmacological potential with a great utility and usage as folklore medicine. The phytochemical investigations showed the presence of saponins, tannins, steroids, alkaloids, flavonoids, phenols and glycosides. Atropine and scopolamine are competitive antagonists of muscarinic cholinergic receptors and are central nervous system depressants. The present paper presents an exclusive review work on the ethnomedical, phytochemical, pharmacological activities of this plant.

Research frontiers

From the time of immemorial, plants have been widely used as curative agents for varieties of ailments. Present study gives a broad information about the bioactive constituents, ethnopharmacology along with the scientifically claimed medicinal uses of *D. stramonium*.

Related reports

This review work may facilitate the enrichment of concept and the possible outcome from the use and consumption of *D. stramonium*. The content is different from that of Maibam Rasila Devi1 *et al* and Das Sanjita *et al* 2012, who also described the neurotoxic properties and medicinal properties of *D. stramonium*.

Innovations and breakthroughs

Jimson weed is a plant with both poisonous and medicinal properties and has been scientifically proven to have great pharmacological potential with a great utility and usage as folklore medicine. This plant has been used in curing different types of diseases. The alkaloids isolated from the plants are also found to be toxic to the animals and 48 alkaloids have been determined in total.

Applications

This review papers advancing knowledge of *D. stramonium* in respect to their ethnomedical, phytochemical, and pharmacological activities.

This review paper provides complete information of this plant regarding ethnomedical, phytochemical, and pharmacological activities to researchers.

Peer review

From the time of immemorial, plants have been widely used as curative agents for varieties of ailments. Present review gives a broad information about the bioactive constituents, ethnopharmacology along with the scientifically claimed medicinal uses of *D. stramonium*. The contents of paper are highly beneficial to scientists who want to work on this plant.

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