Middle East Research Journal of Engineering and Technology
ISSN **2789-7737 (**Print) | Open Access
Frequency: Bi-Monthly
DOI: 10.36348/merjet.2021.v01i01.002

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Pharmacological, Biopesticide and Post-Harvest Loss Management Application of Jimsonweed (Datura Stramonium)

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ABSTRACT: Datura stramonium is one of the most intriguing, in part because of its well-known therapeutic and psychoactive properties in the treatment of many diseases. Datura species have been found to exhibit a variety of biological activity. Insecticide, fungicide, antioxidant, antibacterial, hypoglycemic, and immune response boosting properties have been linked to the genus' species. These effects are linked to the existence of secondary metabolites such as terpenoids, flavonoids, with anolides, tannins, phenolic compounds, and tropane alkaloids, which are the most prevalent atropine and scopolamine in the genus Datura. Ingestion of jimson weed produces the toxidrome of anticholinergic intoxication. Understanding and recognizing the classic signs and symptoms of anticholinergic intoxication can help clinicians evaluate persons presenting with jimson weed poisoning. Moreover, this review is to identify the most important phytochemical substances extracted from the jimsonweed and to characterize their biological activity for health effect and biopesticide application. This is because bio-pesticides are less harmful than chemical pesticides because they do not leave harmful residues, generally target one specific pest or a small number of related pests versus broad spectrum chemical pesticides that affect, in addition to the pest, other beneficial insects, birds, mammals, or non-target species, are effective in smaller quantities, decompose quickly and do not cause environmental problems, and are often cheaper than chemical pesticides. In conclusion, Datura stramonium, beside its medicinal value, can applicable for biopesticide application and for post-harvest loss control of insects such as weevil.

Keywords: Datura stramonium; phytochemical components, pharmacological potential; Biopesticide; weevil.

REVIEW PAPER

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How to cite this paper:
Melaku Tafese Awulachew.; "Pharmacological, Biopesticide and Post-Harvest Loss Management Application of Jimsonweed (Datura Stramonium)". Middle East Res J. Eng. Technol, 2021 Nov-Dec 1(1): 9-17.

Article History:
| Submit: 12.11.2021 |
| Revised: 20.11.2021 |
| Accepted: 28.11.2021 |
| Published: 21.12.2021 |

INTRODUCTION

The world population is expected to rise to approximately 10 billion people by 2050; more than half of this increase is expected to occur in Africa, which equates to an approximately additional 1.3 billion people on the continent. Hence, more people will have to be fed in next few decades more food is projected to be needed to feed and access to vaccines the world than was needed know. The phytochemical and ethnopharmacological properties of the jimson plant have always piqued people's curiosity [1]. The genus has 14 species of annual herbs and perennial shrubs ranging in height from 1 to 1.5 meters, with straight stems, thorny fruits, foul-smelling leaves, and highly scented trumpet-shaped flowers that bloom at the stem forks [2]. Datura plants thrive in nitrogen-rich soils and soils that have been disturbed by human activity, such as agricultural soils, roadsides, and animal pens [3]. Steroids, phenolic compounds, fatty acids, withanolides, and lactones are the most common components; however the genus is best recognized for producing tropane-type alkaloids [4]. Therefore, this paper aims to identify the main phytochemical components isolated from the Jimson weed (Datura stramonium) and describe their activity against Biopesticides and medicinal effect, with an emphasis on the relevant literature.

REVIEW

Overview of Jimson weed

Jimson weed (Datura stramonium), is a wild growing herb that contains belladonna alkaloids. Recently there have been reports of intentional ingestion of Jimson weed by adolescents for psychedelic purposes. When seen in the emergency department, these patients appear with physical signs of atropine-like poisoning, disturbances of thought and hallucinations. Diagnosis depends on a positive history, if available, and recognition of anticholinergic effects. Differentiation from lysergic acid diethylamide ingestion and schizophrenia is important. Physostigmine, an anticholinergic agent, can reverse both central and peripheral manifestations of Jimson weed intoxication. Ingestion of jimson weed (Datura stramonium) is fairly common and can lead to intoxication and to anticholinergic manifestations that are potentially dangerous. Understanding the signs and symptoms of jimson weed toxicity can lead to early diagnosis and proper case management. Datura stramonium (Figure-1).

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

Phytochemical components and pharmacological potential of

The chemical components (metabolites) present are linked to the biological functions assigned to the genus Datura. Plants create these chemicals in both their primary and secondary metabolism [5]. Plants' primary metabolites play a direct role in their growth, development, and reproduction, whereas secondary metabolites play an ecological role [6]. Different classes of chemicals, such as terpenoids, flavonoids [7], steroids [8; 9], lectins [10; 11], glycosides, fatty acids, saponins [12], tannins [13], phenolic compounds [14], withanolides [15], and various volatile terpenes [16; 17], have been identifie d in Datura species.

Phenolic compounds

In methanolic and hydroalcoholic extracts, the existence of distinct classes of phenolic chemicals in the genus Datura has been demonstrated. Flavonoids, tannins, and glycosidic phenolic substances are found in D. metel and D. stramonium [12].

In diverse solvent fractions such as ethyl acetate, butanol, hexane, chloroform, and methanol, Hossain *et al*. [14] investigated the existence of phenolic compounds in D. metel. Gallic acid, vanilic acid, quercetin, and ferulic acid were identified as the primary phenolic components in methanolic extracts of D. metel roots and leaves [18].

On the other hand, LC-ESI-MS/MS analysis of the methanolic extract of D. innoxia aerial organs revealed the presence of 20 distinct phenolic compounds, with (-)-Epicatechin, (+)- Catechin, Hyperoside, and p-Coumaric acid being the most abundant metabolites detected [19].

Withanolides

Withanolides are steroidal lactones that have been identified from various Solanaceae genera [20]. Biological actions such as anti-inflammatory, antioxidant, anticancer, insecticide, antifood, and immunosuppressive characteristics have been found for these substances [20]. Within the genus Datura (daturalactones), various withanolides have been identified and described, distinguishing themselves by having an epoxy in the lactone ring [21]. Five withanolides were discovered in the aerial portions (flowers, leaves, and stems) of D. quercifolia Kunth that have modest cytotoxic and prooxidant effects, as well as acetylcholinesterase inhibitory activity [22].

Many previously unknown withanolides have been extracted from D. metel leaves, and two of them have shown anti-inflammatory action [23]. In addition, thirteen other withanolides were isolated from D. metel flowers and showed immunosuppressive properties against splenocyte proliferation in mice, as well as activity in vitro against human gastric adenocarcinoma cell proliferation (SGC-7901), human hepatoma (HepG2), and human breast cancer (MCF-7) [24].

Terpenes

Datura produces volatile substances that protect plants from herbivore harm by having varying quantities and types of glandular and non-glandular trichomes [25]. D. wrightii contains seventeen volatile chemicals, the majority of which are sesquiterpenes (Figure 2), such as limonene, linalool, (E)-3,8-dimethyl-1,4,7-nonatriene (DMNT), and (E)—ocymene, with (E)—caryophyllene being the most common [25].

Lectins

Lectins are a group of carbohydrate-specific binding proteins that have been isolated from D. stramonium and other Solanaceaes [26]. There are controversies regarding the biological role of lectins, although a defensive role for plants has been proposed due to the toxicity of lectins in both mammals and insects [27].

D. stramonium agglutinin (DSA) is a chitin-binding lectin that has been extracted and purified from D. stramonium seeds [60]. The use of D. stramonium agglutinin in lectin microarrays has been used in the identification of renal pathologies in diabetic patients. Results of lectin microarrays revealed that Nacetyl-D-glucosamine (GlcNAc) linked to (β-1,4)-linked N-acetyl-D-glucosamine recognized by lectin D. stramonium agglutinin (DSA) was significantly higher in patients with diabetic nephropathy [28].

Alkaloids

Datura has a diverse phytochemical makeup of tropane-type alkaloids, which are the plant's most potent chemicals [29; 30].

Tropane alkaloids, in particular, are a collection of roughly 200 alkaloids with a tropane ring (N-methyl-8-azabicyclo in their chemical structure, with L-ornithine as the major precursor [64]. Atropine (hyoscyamine) and Scopolamine (hyoscine) are the most prevalent alkaloids in the genus Datura [31].

The alkaloid fraction of D. ceratocaula revealed 36 compounds with a distinctive mass fragmentation spectrum, with Atropine being the most abundant alkaloid in seed and Scopolamine being the most abundant alkaloid in flowers [32]. Atropine and scopolamine were found in similar abundances in D. ferox, with 0.32 g of scopolamine per 100 g of dry plant material [33].

Scopolamine and Atropine were the major alkaloids, with quantities changing based on the region of the plant [34]. The most abundant alkaloids in D. quercifolia are Tropinone, Tropine, Pseudotropine, Atropine, and Scopolamine [35].

In the species D. stramonium, at least 67 tropane alkaloids (table 1) have been found in various sections of the plant. Tropine, 3-Tigloyloxy-6-propionyloxy-7-hydroxytropane, 3,6-Ditigloyloxy-7-hydroxytropane [36] has been identified as the most prevalent, alongside atropine and scopolamine. Okwu and Igara [37], on the other hand, discovered one steroidal alkaloid in D.metel that had antibacterial activity.

Table-1: Most abundant tropane alkaloids identified in the genus Datura [35, 31, 36]

Alkaloid	Specie	Organ
Scopolamine	All	Roots, leaves, flowers, and seeds
Atropine	All	Roots, leaves, flowers, and seeds
3-Tigloyloxy-6,7-dihydroxytropane	Datura stramonium	Roots
Apoatropine	Datura stramonium	Roots, leaves, flowers, and seeds
3-Tigloyloxy-6-hydroxytropane	Datura stramonium	Roots
Hyoscyamine	Datura quercifolia	Roots, leaves, flowers, and seeds
3α-Tigloyloxy-6-isovaleroyloxy-7-hydroxytropane	Datura stramonium	Roots
3,6-Ditigloyloxy-7-hydroxytropane	Datura stramonium	Roots
Scopolamine	Datura stramonium	Roots, leaves, flowers, and seeds
Tropine	All	Roots, leaves, flowers, and seeds
3-acetoxynortropane	Datura quercifolia	Roots

The Biological functions of the Datura

Insecticide action

Different writers have looked at the insecticidal and repellant properties of Datura species. In contact and spray application experiments, leaf extracts of D. metel (acetone, water, and petroleum ether) have been shown to exhibit insecticidal and insect repellent activity against a variety of insect species. In organic extracts of D. metel, EC50 values of 12,000 ppm for grasshoppers and 11,600 ppm for red ants were found [30]. In the case of D. stramonium, pesticide activity has been assessed in non-polar extracts in adult individuals and larvae of various insects, both by contact and by food [27].

The larvicidal efficacy of D. stramonium aqueous root extract was tested on two mosquito species and found to be between 50 and 100 percent larval mortality at 100 percent concentration of the extracts 24 hours after treatment [38]. Different quantities of an aqueous extract of D. stramonium leaves and seeds were shown to be effective against flea beetles, a common maize pest [39].

The effect of acetone extracts from Datura inoxia was evaluated against Tribolium castaneum, Trogoderma granarium and Sitophilus granarius where the toxic effect of the plant extracts was observed in addition to the inhibition of enzymes acetylcholinesterase (AChE), α-carboxylesterase (α-CE), β-carboxylesterase (β-CE), acid phosphatases (ACP) and alkaline phosphatases (ALP) in toxicity test survivors showing lethal effects against three stored grain insect species by up to 15% lethality associated to a significant effects on AChE inhibition, α-EC, β-EC, ACP and ALP at different concentrations [39].

Herbicidal

In aqueous and methanolic extracts, D. metel has shown possible herbicidal efficacy against "noxious weed parthenium," with the root showing superior effects to the stems, with both extracts reducing weed germination as well as stem development in individuals of a few weeks [1]. Similarly, germination inhibition was seen in methanolic and hexane root extracts of D. metel when it was tested for herbicide action against Phalaris minor.

Sakadzo *et al*. [40] found that an aqueous extract of D. stramonium inhibited root development, plumule length, and dry matter amount in Amaranthus hybridus and Tegetes minuta, with herbicidal effects both pre- and post-emergence.

Acaricide activity

The methanolic extracts of D. stramonium leaves and seeds showed acaricidal effects, with 98 percent mortality of adult Tetranychus urticae Koch (spider mites) in the leaf extract and 25 percent mortality in the seed extract, with a direct relationship between concentration and mortality rate for the leaf extracts but not for the seed extracts [7].

In adult mite immersion trials, an ethanolic extract from Datura stramonium leaves caused 20% mortality against Rhipicephalus microplus (Asian blue tick) [41]. In vitro experiments showed that the methanolic extract of D. stramonium inhibited the oviposition of Rhipicephalus (Boophilus) microplus by 77% [42].

Antifungal activity

Three members of the genus, D. discolor, D. metel, and D. stramonium, were tested for antifungal activity. Ethanolic and methanolic extracts from D. discolor stems and leaves were combined with culture medium to prevent the growth of Aspergillus flavus, Aspergillus niger, Penicillium chrysogenum, Penicillium expansum, Fusarium moniliforme, and Fusarium poae [12].

Rhizoctonia solani was inhibited by aqueous and methanolic extracts of D. metel leaves. D. metel's methanolic extract was up to 35 percent more toxic than the other 15 species investigated, preventing mycelial growth and being used in agriculture (herbicide, acaricide, insecticide) and medicine (antibacterial, cytotoxic, or antioxidant). Production of sclerotium [15].

Furthermore, extracts of all parts of D. metel in various solvents (hexane, chloroform, acetone, and met hanol) showed antifungal activity against three Aspergil lus species: A. fumigatus, A. Niger, and A. flavus, with the chloroform fraction having the lowest inhibitory con centration (MIC) of 625.0 g/mL [43].

The growth inhibition of five fungal species: A . flavus, A. niger, Alternaria solani, Fusarium solani, an d Helianthus sporium was used to assess the antifungal efficacy of methanol extracts from the leaves, seeds, ste ms, and roots of D. inoxia [44].

The antifungal activity of D. stramonium extra cts on Candida albicans was stronger in aqueous extract s (74 percent), while methanol and chloroform extracts had good inhibitory activities (69 percent and 65 percen t, respectively) [45].

Antibacterial activity

D. stramonium leaf and fruit extracts with different polarity solvents were tested against 5 pathogenic bacteria, with the extracted methanol and chloroform fractions from both leaves and fruits showing growth suppression of all tested microorganisms at various doses. All isolated fractions from the fruits efficiently inhibited the growth of Pseudomonas aeruginosa and Klebsiella pneumonia. The chloroform extract of leaves showed the greatest growth inhibition (77%) against K. pneumonia [45].

Using the paper disk diffusion method and ampicillin as a positive control, antibiotic activity of methanolic extracts (80%) of Datura inoxia against Bacillus subtilis, Staphylococcus aureus, and Escherichia coli was determined. Except for E. coli (2.5 g/mL), the results showed action against all bacteria at the greatest concentration of the extracts [46].

In the paper disk diffusion method, however, methanolic, ethanolic, and aqueous extracts of D. stramonium showed antibacterial activity against gram-positive and gram-negative bacteria. With a minimum inhibitory concentration of 25% w/v, ethanolic extract of leaves inhibited the growth of bacteria in P. aeruginosa, K. pneumoniae, and E. coli [47]. At 2.5, 1.25, and 0.75 mg/mL, the methanolic leaf extract showed antibacterial activity against gram-positive bacteria such as Staphylococcus haemolyticus, S. aureus, Shigella dysenteriae, and Bacillus cereus, as well as gram-negative bacteria such as P. aeruginosa, K. pneumoniae, and E. coli [13].

Antioxidant activity

Aqueous extracts of D. metel stems, roots, and leaves had antioxidant activity ranging from 23.8 to 49.3% [48]. D. stramonium methanolic extract had IC50 values of 35.3, 10.5, and 49.36 g/mL for radical DPPH, superoxide, and radical cation ABTS, respectively [49]. In comparison to D. metel, the antioxidant capacity and concentration of phenolic compounds and flavonoids, as well as the higher antioxidant capacity (221.25 1.06 mg EPA/g), were tested in D. innoxia, which had significantly higher values in all assays [50]. The presence of the maximum number of phenolic components, including flavonoids and tannins, in D. metel leaf methanol extract exhibited the highest antioxidant capacity in a DPPH purification test against other solvents and plant parts [51].

Hypoglycemic activity

The hypoglycemic action of D. metel seeds was investigated by adding pulverized seeds to the food of rats with induced diabetes, which resulted in a considerable decrease in blood glucose levels after 8 hours [52]. Although a hydromethanolic extract of D. stramonium root was tested in diabetic mice and found to have no substantial hypoglycemic effect, the extract considerably lowered blood glucose levels in diabetic by orally loaded mice at relatively large doses (100, 200, and 400 mg/kg) [53]. The antihyperglycemic effects of D. inoxia methanolic leaf extract were seen in -glucosidase, -amylase, lipase, and urease [54].

Cytotoxic activity

The ethyl acetate portion of the ethanolic extract of D. metel flowers was tested against cancer cell lines and found to be cytotoxic against the A549 (tongue), BGC-823 (gastric), and K562 (leukemia) cell lines [55]. Similarly, methanolic extracts of Datura stramonium seed were found to be cytotoxic to MCF7 (breast cancer) cells, with a cytotoxicity of 66.84 percent at 599 ug/mL [49]. These findings were similar to those reported by Gupta *et al*. [56], who investigated the cytotoxic effects of methanolic extracts of D. stramonium leaves on A549 and MCF7 cells, finding considerable immunostimulation [57]. The methanolic leaf extract of D. innoxia revealed a possible cytotoxic impact on MCF-7 human breast cancer cell lines, with an IC50 of 93.73 g/ml [57].

Rhinoxia B, a phytosterol isolated from D. inoxia leaf extracts, was found to have antiproliferative activity against human colon adenocarcinoma cells, HCT 15, with an IC50 of 4 M [56].

Other Activities

Datura has anticholinergic (mydriatic, antispasmodic), anesthetic, analgesic, sedative-hypnotic, anti-parkinsonian, and aphrodisiac qualities due to the presence of tropane alkaloids. Tropane alkaloids' actions are linked to a competitive antagonist of muscarinic receptors. Some tropane alkaloids and derivatives, on the other hand, have exhibited differing affinities to the nicotinic acetylcholine receptor, albeit to a lesser amount, and are in some cases partial agonists [58]. Tropane alkaloids' nervous system effects are also linked to the action of monoaminergic neurotransmitters, as tropane alkaloids exhibit varying degrees of affinity for monoaminergic transporters [59].

DISCUSSION

Jimson Plant in Ethiopia

Ethiopia is primarily found in the tropical and subtropical regions of the world. As a result, the climatic conditions are favorable for the growth of the Jimson plant, and around 35-45 percent of Ethiopia's climate is suited for the jimson plantation. In Ethiopia, Jimson plant has been seen in a number of locations. Oromia, Gambella, Somalia, Southern Nations, Nationalities and Peoples, Sidama, and Amhara [60] are just a few of the locations where it can be found. Extracts of Datura stramonium are utilized in traditional medicine for their biological activity.

Bio-pesticide based on atropine

In 1850, a Belgian chemist named Jean Servial Stas was the first to successfully isolate an alkaloid poison, extracting nicotine from the tissues of the murdered Gustave Fougnie with a mixture of acetic acid and ethyl alcohol. To keep pests away from plants and crops, Jimson seed is used as a pesticide. This method is effective against insecticide-resistant pests while causing no harm to beneficial insects. Jimson oil and seed extracts, which are used to make pesticides, are known to have germicidal and antibacterial capabilities, making them useful for protecting plants from various pests. One of the most significant differences between Jimson-based insecticides and their synthetic counterparts is that they do not leave any residue on the plants. Jimson insecticides are frequently employed in agriculture because they serve an important role in pest management. There has been a noticeable movement worldwide from synthetic pesticides to non-synthetic pesticides, owing to widespread understanding of the synthetic pesticides' adverse effects not just on plants and soil, as well as other living organisms.

Because Atropine has multiple modes of action, insect species are unlikely to develop resistance to it based on just one. Most synthetic pesticides, on the other hand, target the insect's nervous system, and resistance to one chemical leads to resistance to all others that use the same response pathway. Atropine has long been thought to be an environmentally beneficial insect pest management strategy for plant protection.

The effect of atropine on pest growth regulation

The ability of Jimson products to control insect proliferation is a fascinating feature. The insect larva feeds and sheds its old skin as it grows. Ecdysis, or molting, is the process of shedding old skin and is controlled by an enzyme called ecdysones. The action of ecdysones is reduced when Jimson components, particularly Atropine, enter the body of the larva, causing the larva to fail to molt, remain in the larval stage, and eventually perish. The larva will only perish after entering the pupal stage if the Atropine concentration is not high enough. If the concentration is any lower, the adult that emerges from the pupa will be completely deformed and sterile [61].

Feeding prevention's atropine effect

An insect larva will seek to feed on a leaf if it is sitting on it. The maxillary glands are responsible for this particular eating trigger. As a result, peristalsis in the alimentary canal is accelerated, and the larva becomes hungry and begins feeding on the leaf's surface. Because Atropine antagonizes the muscarine-like activities of acetylcholine and other choline esters, if the leaf is treated with a Jimson product, it will act as an antimuscarinic agent. The insect does not feed on the Atropine-treated surface as a result of this perception. Its swallowing ability is also impaired [62].

Atropine has an anti-oviposition action

Another way Atropine keeps pests at bay is by stopping females from laying eggs. When seeds in storage are covered with Atropine or crude Jimson oil, this ability is known as oviposition prevention, and it comes in useful. The insects will no longer feed on them after this treatment. Further damage to the grains will be prevented, and the female will be unable to lay eggs throughout her life cycle's egg-laying period.

Anticholinergic Poisoning from Jimson Weed

Symptoms and Signs of Poisoning

Onset of symptoms occurs promptly after ingestion [63]. Dryness of the mouth appears first, and there is marked thirst. Next, the pupils dilate and blurred vision develops. The skin appears warm and flushed. An atropine rash, more common in children, may be seen over the face, neck and chest. The patient may experience difficulty in swallowing, talking and urinating. Palpations and tachycardia become prominent. Fever is usually present and can reach alarming heights in children. Depending on the amount of stramonium taken, varied behavorial and mental symptoms are observed. The patient is restless, confused and agitated. His excitement and hyperactivity may predispose him to weakness and muscular incoordination. Memory and orientation are disturbed, visual hallucinations commonly develop and mania and delirium may follow. With higher doses, coma and convulsions have occurred and death can result from cardiac and respiratory arrest [63]. Generally, the psychosis clears within 12 hours while the clinical abnormalities disappear within 24 to 26 hours. However, the syndrome can last 48 hours or longer [63].

Diagnosis

Certainly, a positive history of Jimson weed ingestion is helpful in diagnosis. Without such information the diagnosis depends on recognition of paralysis of organs innervated by parasympathetic nerves in addition to the bizarre mental symptoms. Stramonium intoxication must be differentiated from lysergic acid diethylamide (LSD) ingestion and schizophrenia. The physical findings of dilated pupils, tachycardia and fever can occur with both Jimson weed and LSD [64]. However, dry mouth and flushed appearance do not generally occur in the latter. Also, in LSD toxicity goose pimples appear from the sympathomimetic effect. Another historically reported diagnostic method is to identify atropine in the patient's urine by placing a drop of urine in the eye of a cat and observing pupillary dilatation [64].

Treatment

Induced emesis is indicated even if it has been several hours since ingestion. If the patient is uncooperative, then gastric lavage with an Ewald tube should be initiated to remove any remaining Jimson weed contents. Despite usually rapid absorption, the belladonna alkaloids produce decreased gastrointestinal motility and may remain in the stomach for prolonged periods. When gastric lavage becomes clear, approximately 5 gm of activated charcoal should be given via the tube to bind unabsorbed material. A cathartic, eg, magnesium sulfate, is then given in order to increase intestinal transit time and decrease absorption. Physical restraints may be necessary to prevent the agitated patient from injuring himself and others. A quiet, darkened environment will keep stimulation to a minimum. Appropriate antipyretic measures should be taken to reduce any fever. Hospitalization is indicated when toxicity is present. As an anticholinesterase agent, physostigmine inhibits the enzyme acetylcholinesterase, thus enabling acetylcholine to accumulate at the neuroreceptor site. Because of its structure as a tertiary amine, physostigmine crosses into the CNS and reverses the hallucinations and mental symptoms [65]. Thus, if the diagnosis is correct, reversal of both central and peripheral effects can be expected within minutes after injection. Neostigmine bromide and pyridostigmine bromide are also anticholinesterase agents but, as quaternary amines, do not enter into the CNS.

CONCLUSION

Datura species are among the oldest plants known to have been utilized in traditional medicine. Because of its psychoactive properties, it has been a source of major cultural traditions. The impacts of jimson plants have been examined in numerous general biological activities, such as pesticide, fungicide, and antibacterial, among others, based on this cultural knowledge. Furthermore, research into plant components has led to research into more critical biological activities such as cancer cell cytotoxicity. The relevance of studying secondary metabolites of the genus Datura has resulted in significant biological discoveries. However, new research continues to uncover new metabolites with potential biological activity in a variety of systems, establishing the genus as a valuable source of chemicals with novel pharmaceutical applications. Those ability of Jimson products to control insect proliferation is a fascinating feature. The insect larva feeds and sheds its old skin as it grows. Overall, beside its medicinal value, jimson weed can applicable for biopesticide application and for post-harvest loss control such as weevil.

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