academicJournals

Vol. 7(39), pp. 2885-2897, 17 October, 2013
DOI: 10.5897/JMPR11.1657
ISSN 1996-0875 ©2013 Academic Journals
http://www.academicjournals.org/JMPR

Journal of Medicinal Plants Research

Review

Rediscovering the medicinal properties of *Datura* sp.: A review

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Accepted 10 February, 2012

***Datura* is known as a medicinal plant and plant hallucinogen all over the world. *Datura* has a very special place in Ayurveda since all parts of the plant namely leaves, flowers, seeds, roots, have been used for a wide range of medication such as treatment of leprosy, rabies, insanity, etc. The extract of *Datura*, however, is a potent poison and its indiscriminate use may lead to delirium and acute poisoning that may lead to death. The active constituents in *Datura* include scopolamine, atropine, hyoscyamine, withanolides (lactones) and other tropanes. Recently, withanolide compounds have shown significant antitumor, cytotoxic, anti-inflammatory, antibacterial, hepatoprotective, sedative, cytostatic and immunosuppressive activity. The present review includes phytochemical investigations and biological activities of various *Datura* species wherein several novel compounds have been isolated, characterized and screened for their biological activities.**

Key words: *Datura*, chemical constituents, alkaloids, biological activities, therapeutic usage.

INTRODUCTION

Datura is a wild weed belonging to family Solanaceae, its name derived from Sanskrit word “Dhutra” (divine inebriation) is used for its healing properties. Various species of *Datura* are known and widely employed for their medicinal and toxic properties that are based upon more than 30 alkaloids. Because of their funnel form, fragrant nocturnal blooms, species such as *Datura inoxia, Datura metel, Datura stramonium* and *Datura wrightii* are cultivated as ornamental plants with all but *D. metel* known from wild populations (DeWolf, 1956). Navajos chewed dried roots to reduce fever. Zunis made poultice from it to treat inflammation and bruises (Del Pozo, 1966). In China, it is known as “Yangjinhua” and used for the treatment of asthma, convulsions, pain, and rheumatism (Pan et al., 2007). *Flos Daturae* has an effect on the treatment of psoriasis for clinical use in China (Guarrera, 1999). It is used in Italy to remove lice from hen bundles. *D. stramonium* seeds are used for acne and bronchitis in Sakarya province of North-west Turkey and locally called “Tatala”, while the petroleum ether extract is also found to possess antimicrobial activities against *Esherichia coli* and *Trachystemon orientalis* by Uzun et al. (2004). It is also used commonly in ethno veterinary practices in Nepal (Raut and Shreshtha, 2012) and by *Gujjar* community in India (Gaur et al., 2010). In Ayurveda, *Datura* plant parts are used to treat various disorders including asthma, skin disorders, jaundice, piles, and diabetes (Dash and Kashyap, 1991). *Datura* seeds have been used as a prophylactic measure to treat animal bites, especially dog bites. Person bitten by mad dog is administered with juice of *Datura* along with butter milk and jaggery. Also, the site of bite is smeared with a paste of the fruit (Papadoyannis, 1995).

Extensive research has been carried out since 1925 for the isolation and characterization of the total alkaloid contents in *Datura* species (Berkov et al., 2006; Dovelana et al., 2006). Vitale et al. (1995) has shown that the total alkaloid content in *Datura* varies from 0.02 to 0.52% and scopolamine from 0.0029 to 0.32% relative to the dried material, depending on the geographical area, the part of the plant studied and the stage of growth.

Attempts have been made to evaluate its various

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Table 1. Alkaloids from roots and leaves of *Datura* spp.

Miscellaneous alkaloids
Hygrine, Tropinone.
Mono substituted tropanes
Tropine
Pseudotropine
3-Acetoxytropane
3-(Hydroxyacetoxy)-tropane
3-(2-Methylbutyryloxy)-tropane
3-Tigloyloxynortropane
3α-Tigloyloxytropane
3 β Tigloyloxytropane
3 α -Phenylacetoxytropane
3 β -Phenylacetoxytropane
Apoatropine
Norapoatropine
Litorine
Hyoscyamine
3-(30-Acetoxytropoyloxy)-tropane
3-(20-Hydroxytropoyloxy)-tropane
3-Substituted-6,7-epoxytropanes
Scopoline
Scopine
Methylscopolamine
3-Phenylacetoxy-6,7-epoxynortropane
Aponorscopolamine
Aposcopolamine
Norscopolamine
Scopolamine
3-(20-Hydroxytropoyloxy)-
3,6-Disubstituted tropanes
3,6-Dihydroxytropane
6-Hydroxyacetoxytropane
3 α -Hydroxy-6 β acetoxytropane
3 β -Hydroxy-6 β acetoxytropane
3,6-Diacetoxytropane
3-Hydroxy-6-propionyloxytropane
3-Propionyloxy-6-hydroxytropane
3-Hydroxy-6-isobutyryloxytropane
3-Isobutyryloxy-6-hydroxytropane
3-Hydroxy-6-(2-methylbutyryloxy)-tropane
3-Hydroxy-6-methylbutyryloxytropane
3-Isovaleryloxy-6-hydroxytropane or
3-(2-methylbutyryloxy)-6-hydroxytropane
3 α -Tigloiloxy-6 β hydroxytropane
3 β -Tigloiloxy-6 β hydroxytropane
3 β -Hydroxy-6 β tigloyloxytropane
3 α -Tigloyloxy-6 β acetoxytropane
3 β -Tigloyloxy-6 β acetoxytropane

Table 1. Contd.

3-Tigloyloxy-6-propionyloxytropane
3 α -Tigloyloxy-6 β isobutyryloxytropane
3 α -Tigloyloxy-7 β isobutyryloxytropane
3-Tigloyloxy-6-(20-methylbutyryloxy)-tropane
3-Tigloyloxy-6-methylbutyryloxytropane
3-Phenylacetoxy-6-hydroxytropane
3 α,6 β -Ditigloyloxytropane
3 β,6β -Ditigloyloxytropane
3 α -Apotropoyloxy-6 β -hydroxytropane
6-Hydroxyhyoscyamine
7-Hydroxyhyoscyamine
3-Tropoyloxy-6-acetoxytropane
6-Tigloyloxyhyoscyamine
6-(2-Methylbutyryloxy)-hyoscyamine
3,6,7-Trisubstituted tropanes
3-Tigloyloxy-6-propionyloxy-7-hydroxytropane
Meteloidine
3,6-Dihydroxy-7-tigloyloxytropane
3 α -Tigloyloxy-6β -isovaleryloxy-7β -hydroxytropane
3β-Tigloyloxy-6β-isovaleryloxy-7β-hydroxytropane
3a,6β-Ditigloyloxy-7β-hydroxytropane
3β,6β-Ditigloyloxy-7β-hydroxytropane

therapeutic potentialities. However, no comprehensive data is available regarding the work done so far. Herein, we describe a brief review on the active chemical constituents of various *Datura species* and their therapeutic potentials. Thus this review would help in designing new drug moieties for further research.

During the past ten years, an extensive effort has been put forth for the isolation and determination of alkaloids in plant materials. Using high end techniques such as High Performance Liquid Chromatography (HPLC) and Gas Chromatography Mass Spectroscopy (GC-MS) the alkaloids, tropanes and withanolides have been isolated and given in Table 1.

Some of the novel compounds isolated from *Datura* species are mentioned in the subsequently. Siddiqui et al. (1986) have isolated a new tropane alkaloid containing p-methoxy benzoic acid (datumetin 1) (Figure 2) as an esterifying acid from the *D. metel* leaves.

Not much has been reported about the presence of flavonoid glycosides from *Datura* species. Kaempferol 3-O-α-L-arabinopyranosyl-7-O-β-D-glucopyranoside, kaempferol 3-O-α-L-arabinopyranoside (2) (Figure 3), 3-phenyl lactic acid, 3-(3-indolyl) lactic acid, and its methyl ester, physalindicanol A and physalindicanol B were isolated from methanol extract of leaves of *Datura sauveolens*. Characterization was done using ES-FTICR-MS and 2D-NMR (Begum et al., 2006).

Quercetin, chrysin, naringenin and liquiritigenin are

some of the flavonoids isolated from *D. stramonium* L; while *Datura innoxia* Mill contains luteolin (Wollenweber et al., 2005). There has been reports of various other compounds isolated from various species of *Datura* which includes pentacyclic terpenes such as Daturadiol (3) and Daturalone (4) (Figure 4) (6β-hydroxylated β-amyrin) derivatives (Kocor and Pyrek, 1973).

Withanolides are a group of naturally occurring steroids built on ergostane type skeleton in which C-22 and C-26 are appropriately oxidized forming δ lactone. Four withanolides, namely daturalactone (5-7) (Figure 5) have been isolated from *D. quercifolia* by Dhar and Kalla (1976).

Withametelins (8-15) (Figures 6 and 7), 1,10-seco withametelin B (16) and 12 β-hydroxy- 1,10 seco withametelin B (17) (Figure 8) have been isolated from *D. metel* by Pan et al. Withanolides can inhibit tumor cell proliferation (Jayaprakasam et al., 2003), angiogenesis (Mohan et al., 2004) and induce phase II enzyme quinone reductase (Kinghorn et al., 2004).

Cirigliano et al. (1995) isolated new withanolide from *D. ferox* in Argentina, 15 β-hydroxy nicandrin B (18). The plant also contained withaferoxolide (19), withanicandrium (20), withastramonolide (21) and withametelin E (22) (Figure 9).

Withatatulin (23) a new 21- hydroxyl withanolide have been isolated from the leaves of *Datura tatula* by Manickam et al. (1996); they also isolated with afastuosin F (24) (Figure 10) a new pentahydroxy with anolide 5α, 6β, 12β, 21, 27- pentahydroxy-1-oxo-with a-2,24 dienolide from the methanolic extract of the fresh flowers of *D. fastusosa* (Manickam et al., 1998).

Isolectins have been isolated from *D. stramonium* seeds. Two of these lectins are homodimers made up of either A/B subunits while the third is a heterodimer composed of one A and B subunit with approximate molecular weights of 32,000 and 28,000 respectively ((Broekart et al., 1998)). *Datura* lectins show its greatest affinity for glycopeptides. The different domains contain many contiguous hydroxyproline residues which are glycosylated and other which lack glycosylated residues, have higher proportions of cysteine residues containing the binding sites.

The structure of the glycosylated region of these lectins is similar to that of hydroxyproline rich glycopeptides of plant cell wall and these lectins could be precursors for such material (Desai et al., 1981).

PHARMACOLOGICAL ACTIVITY

Atropine (25) is the racemic form of (-)-hyoscyamine (27) (Figure 11). It binds competitively to muscarinic receptors blocking parasympathetic cholinergic neurons. It acts on both peripheral and central muscarinic receptors. In lower doses, it affects cardiovascular system causing bradycardia. Atropine increases acetylcholine release (cholinesterase inhibitors) and hence used as an antidote to treat organophosphate poisoning, to dilate the pupil, decrease the salivation and to reduce the gastrointestinal activity (Bliss, 2001).

Hyoscyamine and scopolamine (26) (Figure 11) act as anti muscarinic compounds and act on both CNS and peripheral nervous system. Scopolamine is used as CNS depressant in small doses and used to treat motion sickness. Apart from this, other therapeutic implications include antiemetic, antidysmenorrheal, and gastric anti spasmodic. Hyoscyamine is used as an adjunct in Zollinger-Ellison syndrome.

Typical findings in *Datura* poisoning are dryness of the mouth, thirst, flushing, fever, amnesia, urinary retention, decreased salivation, papillary dilation, tachycardia, hallucinations (which are frightening), palpitation, ataxia, delirium leading to coma, cardiac and respiratory arrest and death (Barceloux, 2008).

ANALGESIC EFFECT

Aqueous extract of *D. fastuosa* leaves and seeds (10% w/v) were taken to evaluate the analgesic effect on acetic acid induced writhing pain and hot plate reaction in mice. Oral treatment of 400 and 800 mg/kg proved effective and showed significant analgesic effect. Upon naloxone administration, analgesic effect was reduced in leaf extract while the seed extract remained unaffected. Swiss mice under standard environment conditions were subjected to i.p. acetic acid injection (0.6%, 10 ml/kg) and hot plate to check the analgesic effect (Abena et al., 2003).

Aqueous seed extract of *D. metel L*. was found not to possess analgesic activity on acetic acid induced model as well as the radiant heat tail-flick model (Wannang et al., 2009).

ANTI-VIRAL

Atropine inhibited only the growth of enveloped viruses independent of the nucleic acid content of the virus. The activity of atropine was checked by plaque reduction test and one step growth experiments.

The test viruses included *Herpes Simplex Virus, Influenza virus, New Castle Disease Virus, Sindbis, Vaccinia, Adenovirus, Japanese encephaitis Virus*. Viruses were cultivated on primary chick embryo (CE), HeLa S_3, primary monkey kidney cells (MK) (Yamazaki and Tagaya, 1980).

Atropine also blocks the glycosylaton of viral proteins of *Herpes* virus and hence the production of new infectious virus particles (virions). Virions formed in the presence of atropine are non infectious (Alarcon et al., 1984).

ANTICANCER ACTIVITY

Chemical investigation of a methanol extract of the flowers of *D. metel* by Pan et al. has led to the isolation of

10 new withanolides I-P (1-8), 1-10-seco-withametelin B (9) and 12 β-hydroxy-1,10-seco-withametelin B (10) together with seven known withanolides. The structures where elucidated using spectroscopic data, while single crystal X-ray analysis was done for structure 9. The compounds where screened against various cancer cell lines including A549 (lung), BGC-823 (gastric) and K562 (leukemia). Compounds 1, 3, 4 and 6 exhibited cytotoxic activities with their IC_{50} values ranging from 0.05 to 3.5 μM (Table 2).

Sasaki et al. (2002) have found that *D. stramonium* agglutin (DSA (lectin)) induced irreversible differentiation in C6 glioma cells. The differentiated cells had long processes, a low rate of proliferation and a high content of glial fibrillary acidic protein. Experiments with several other lectins indicated that both recognition of linear N-acetyllactosamine repeats and recognition of multiantennary units of cell-surface glycans were required for the inhibition of C6 proliferation. Proliferation of four human glial tumor cells was also inhibited by DSA, which suggests its usefulness as a new therapy for treating glioma without side effects.

Li et al. (2005) isolated endophytic fungi from *D. stramonium* and tested for the antitumor activities by MTT assay on human gastric tumor cell line BGC-823, which exhibited 100% growth inhibition rate.

Iman Ahmad et al. (2009) recently carried out studies on human cancer cell lines *in vitro* on MDA-MB231 (breast), and FaDu (neck). The treatment with *D. stramonium* aqueous leaf extract for 24 and 48 h showed increase in GSSG in FaDu cells indicating oxidative stress in treated cells.

WOUND HEALING PROPERTIES

In vivo healing potential of *Datura alba* alcoholic extract on burn rat wounds were studied (Shanmuga et al., 2002). A 10% w/w ointment was prepared and applied topically on thermal wounds. Complete wound healing was observed within 12 days in treated rats against control rats which required about 30 days for healing. Apart from antimicrobial activity, studies were carried out to check rate of wound contraction and histochemical analysis to examine cellular infiltration. Biochemical assays to check collagen and hexosamine content of tissue on various days were carried out by using gelatin zymography. The antimicrobial assay done by disc diffusion method of the crude extract showed antimicrobial activity on pathogenic organisms obtained from burn patients. Silver sulfadiazine (1 mg/ml), DMSO and solvents used for fractionation were also tested simultaneously. The pathogens isolated from Burn ward unit, Child Trust Hospital, Chennai were *Staphylococcus* sp., *Klebsiella* sp., *E. coli, Streptococcus* sp., *Pseudomonas* sp., *Salmonella* sp. and *Vibrio* sp.

Wound healing was increased due to enhanced epithelialisation. The crude extract has enhanced chemotactic effect which attracted inflammatory cells towards the wound site and cellular proliferation was observed by hematoxylin and eosin staining. Increase in cellular proliferation may be due to mitogenic effect of the plant extract. Increase in hydroxyproline content was observed which indicates the increase in collagen synthesis which is essential for wound healing. Matrix metalloproteases (MMP's) such as MMP 9 were expressed in early days, and MMP 2, a 72 kDa gelatinase were also observed. MMP's are helpful in removal of fibrin and eschar which results in formation of peptides which are known to have angiogenic and chemotactic properties. The presence of gelatinase indicates progression of wound healing process.

ANTIPERSPIRANT ACTIVITY

Anticholinergic compounds have antiperspirant action (Mac Millan et al., 1964). Various compounds have been studied and esters of cholinergic compounds have been found to be more effective. Scopolamine hydrobromide is found to be most effective due to its skin penetration ability.

ANTI QUORUM SENSING ACTIVITY

One of the way to check anti pathogenic effect of medicinal plant is to check anti-quorum sensing activity of the extracts (Adonizio et al., 2006). A wide range of plants were selected of different families for their anti quorum sensing activity. Plant chosen from Solanaceae was *D. metel* L. Double purple, c.v. from South Florida. Ethanolic and aqueous extract of flowers and leaves were used to check the activity. Biomonitor organisms used were *Chromobacterium violaceum* and *Agrobacterium tumefaciens* NTL4 (pZLR4). Bioassay was done using disk diffusion method where *C. violaceum* (wt), CV026 supplemented with AHL and *A. tumefaciens* NTL4 supplemented with AHL and X-gal. The plates were incubated overnight and QS was observed by a ring of colourless but viable cells around the disc. *D. metel* did not show anti-QS activity, but the extracts are known to have anti microbial activity which indicates other mechanism of inhibition.

HYPOGLYCEMIC EFFECT

In vivo hypoglycemic and anti-hyperglycemic effect of *D. metel* seeds were studied (Krishnamurthy et al., 2004). Experiments were carried out on normal and alloxan induced diabetic rats. Alloxan is a β-cytotoxin and induces diabetes chemically through the damage of insulin secreting cells. Seed powder extract were tested on both normoglycemic as well as alloxan induced hyperglycemic rats to compare whether excess hypoglycemic effect is

Table 2. Cytotoxicity of Withametelins against three human cancer cell lines.

Merge	Human cancer cell lines (IC_{50} μM)[a]		
	A549	BGC-823	K562
Withametelin I	1.2	1.3	0.05
Withametelin K	3.5	1.9	0.12
Withametelin L	2.0	1.6	0.55
Withametelin N	1.7	1.0	0.46
Adriamycin	0.75	0.35	0.58

Compounds 5, 7, 8, 9, and 10 exhibit no cytotoxicity (IC_{50} > 10 μM).[a] IC_{50} is the concentration of agent that reduced cell growth by 50% under the experimental conditions.

Table 3. Effect of different doses of 2 on spleen T-cell subtypes.

Doses of 2 (mg/kg)	$CD4^+$T-cell (%)	$CD8^+$ T-cell (%)	CD4/CD8 ratio	Spleen $CD4^+$ content ($\times10^7$)	Spleen $CD8^+$ content ($\times10^7$)
Control (vehicle)	20.7 ± 0.90	13.3 ± 0.34	1.56 ± 0.09	2.70 ± 0.12	1.4 ± 0.04
Levamisole (2.5 mg/kg)	30.8 ± 1.30[a]	18.3 ± 0.53[a]	1.68 ± 0.06[a]	1.48 ± 0.10[a]	1.38 ± 0.010[a]
0.1	32.2 ± 0.59	12.6 ± 0.38	2.55 ± 0.07	1.55 ± 0.06	0.95 ± 0.03
1	27.2 ± 0.59	13.6 ± 0.38	2.00 ± 0.07	1.31 ± 0.06	1.02 ± 0.03
2.5	20.3 ± 0.63	15.4 ± 0.69	1.32 ± 0.07	1.02 ± 0.07	0.86 ± 0.04
3	19.7 ± 0.63	13.6 ± 0.69	1.44 ± 0.06	0.90 ± 0.02	1.02 ± 0.07
10	15.1 ± 1.93[b]	25.8 ± 0.35[b]	0.58 ± 0.09	0.72 ± 0.02	1.94 ± 0.06

n = 6; [a], $p<0.01$; [b], $p<0.05$.

hypoglycemic effect is lethal. Gliclazide was used as control to reduce blood glucose level. Histopathological studies were not performed and hence detail mechanism of action could not be studied. Effect of seed powder showed rapid normalization of blood glucose level. Possible mechanism could be that some of the β-cells might have survived the damage and secreted insulin when treated with seed extract. Further studies need to be carried out to check the exact mode of action and the active component participating from the seed extract and to check the synergistic action of the components present in the seed extract. Investigation on Insulin release and enzyme inhibition activity also needed to be studied.

IMMUNOMODULATORY ACTIVITY

Phytochemical investigations of *D. quercifolia* has led to the isolation and characterization of several *Datura* lactones, which are of withanolide skeleton by Bhat et al. (2005). Phytochemical investigation yielded a new *Datura* lactone, 1β,5α,12α-trihydroxy-6α,7α, 24α, 25α-diepoxy-20S, 22R with 2-enolide (5) along with two known compounds, 3 and 4. These compounds were evaluated for their immunomodulatory activity by observing the B and T-cell activation and cytokine production from splenocytes. Of the three compounds isolated, Compound 4 showed dose related increase in primary and secondary antibody production, while Compound 5 act as a suppressor where levamisole was use as standard which increases primary and secondary antibody production. Compound 3 showed higher SRBC induced DTH response at a dose of 0.1 mg/kg p.o. BMS (Betamethasone) was used as standard (Table 3). Compound 3 was checked for the activation of spleen T-cell sub types, CD4 and CD8, selective release of cytokines, IL-2 and TNF-α. It stimulated and showed increase in CD4+ T-cell count and stimulated increase in IL-2 and TNF-α in dose dependent manner (0.01 mg/kg was found more effective) (Figure 1).

ANTI ULCER

Investigation was done to evaluate anti ulcer activity and its mechanism on various models on experimentally induced ulcers in rats (Falcao et al., 2008). W.E. (20 mg/kg) reduced the ulcer and ulcer index significantly in rats. It decreased the volume of gastric secretion, acid and peptic output significantly; it did not affect the mucin secretion and total mucosal glycoprotein content in terms of total carbohydrate, protein gastric cell shedding or cell replication. It also augments prostaglandins.

ANTI- STRESS

Withanolides from *D. fastuosa* possess anti-stress activity (Manickam et al., 1997; Ratan et al., 2011). When administered with diazepam, it exhibited an axiolytic effect

Table 4. Open field behaviour of control and treated group of animals.

Group	Ambulation	Rearing
Control	67.8 ± 7.65	11.17 ± 2.79
Diazepam	98.66 ± 13.25[a]	27.5 ± 1.67[c]
Withafastuosin D	134.16 ± 13.31[b]	34.17 ± 4.15[c]

[a], p<0.005; [b] p<0.01; [c], p<0.001.

Table 5. Effect of test drug on adrenal corticosterone levels.

Group	Corticosterone (µg/100 mg)
Control (untreated group)	5.4 ± 0.37
Restraint control (propylene glycol-H_2O mixture 1:1)	2.72 ± 0.40
Diazepam + restraint stress	4.98 ± 0.5 [b]
Withafastuosin D + restraint stress	4.20 ± 0.34[a]

[a], p<0.05 compared with restraint control; [b], p<0.01 compared with restraint control.

Table 6. Minimum inhibitory concentrations (µg/ml) of *D. innoxia* leaf extract.

Microbe	Ethanol extract	Methanol extract	Ethyl acetate extract
E. coli	> 1024	512	-
S. aureus	256	<128	256
B. subtilis	512	256	>1024
B. cereus	512	256	512

effect and inhibited the immobilization stress induced depletion of adrenal cortisone (Table 4). Adrenal cortisone help organism to overcome annoying stimuli, but such responses can cause stress induced disorders. Detailed study of varying doses, duration and mode of administration is essential to know the effectiveness as an anti stress agent (Table 5).

ANTI-MICROBIAL ACTIVITY

A new antibacterial agent, 5',7' dimethyl 6'-hydroxy 3', phenyl 3 α-amine β-yne sitosterol (28) (Figure 12) was isolated by Okwu and Igara (2009) from *D. metel* leaves. The structure was established using ^{13}C, ^{1}H NMR, IR and MS spectroscopic studies. This compound displayed antibacterial activity against *Staphylococcus aureus, Pseudomonas aeruginosa, Proteus mirabilis, Solmonella typhi, Bacillus subtilis and Klebsiella pneumoni*a but could not inhibit *Escherichia coli*.

In vitro antibacterial activity of aqueous as well as organic extract from various plant parts of *D. innoxia* was checked. Gram negative bacteria such as *P.aeruginosa, E. coli, K. pneumonia, S. typhi, Enterococcus faecalis, Vibrio* sp.*, .Proteus vulgaris,* while the Gram positive: *B. subtilis, S. aureus, Bacillus cereus* were evaluated by Kaushik and Goyal (2008). It was found that the organic extracts from leaves are more potent inhibitors and displayed better antibacterial activity as compared to the stems and roots. Methanol extract shows more inhibition (Table 6). While chloroform extract is found to be active against *Aspergillus flavus, Aspergillus niger, Aspergillus fumigatus. Candida albicans* (Eftekar et al., 2005).

Acetone extracts of *D. stramonium* plant parts were tested against *Vibrio cholerae* and *Vibrio parahaemolyticus* by Sharma and Patel (2009). The crude plant extracts exhibited a MIC of 2.5 to 15 µg/ml. The assays were done by disc diffusion method.

Banso and Adeyemo (2006) have also assessed the phytochemical components and antimicrobial activity of *D. stramonium* ethanolic leaf extract against *P. aeruginosa, K. pneumonia* and *E. coli*. It was recorded that higher concentrations of the extracts were required to inhibit growth. Antimicrobial substances may affect the synthesis of peptidoglycan around the bacterial cell, and the cell dies by osmotic shock. The MIC of the plant extracts ranged from 15 to 25% w/v.

ANTIFUNGAL ACTIVITY

The hexane, chloroform, acetone and methanolic fractions of *D. metel* L. were investigated for antifungal properties against three species of *Aspergillus, that is, A. fumigates*, *A. flavus*, and *A. niger* (Rajesh and Sharma, 2002). The MIC of the chloroform extract was found to be 625.0 µg/ml by microbroth dilution method and 12.5 µg/disc by the disc diffusion assay (Table 7). Although the chloroform extract of *D. metel* was 9.2 time less active than amphotericin B, it was 117.8 times less cytotoxic

Table 7. Activity of chloroform fraction of *D. metel* by disc diffusion method.

Concentration (µg disc^{-1})	Diameter of zone of inhibition (mm)		
	A. fumigatus	***A. niger***	***A. flavus***
$CHCl_3$ fraction			
50.00	9.50	10.00	9.50
25.00	8.50	9.00	8.25
12.50	7.00	7.20	6.75
6.25	-	-	-
Amphotericin B			
2.50	8.23	8.40	8.30
Solvent control	-	-	-

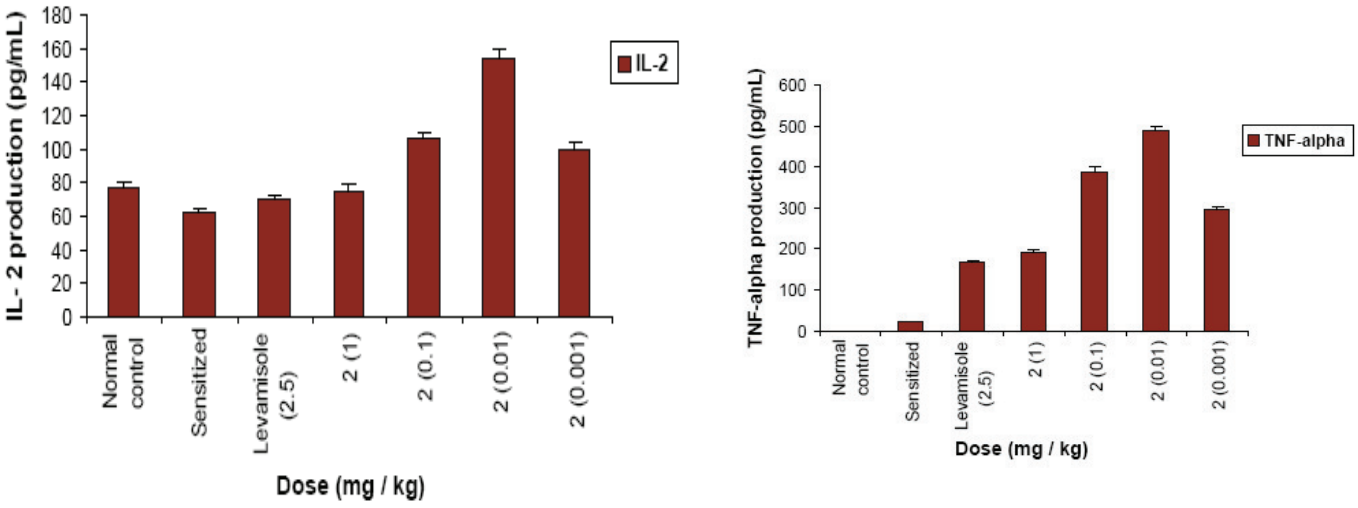


Figure 1. Effect of **2** on IL-2 and TNF-α on cytokine production. Each bar represents the mean value of triplicate readings ± SE. Mouse spleen cells (2×10^6 cells/ml) were stimulated with and without (control) 2.5 µg/well Con-A in the presence of 2 for 48 h. Cell supernatant was collected to see the effect of **2** on the production of IL-2 and TNF-α, measured by commercial kits (Quantikine, R & D SYSTEMS).

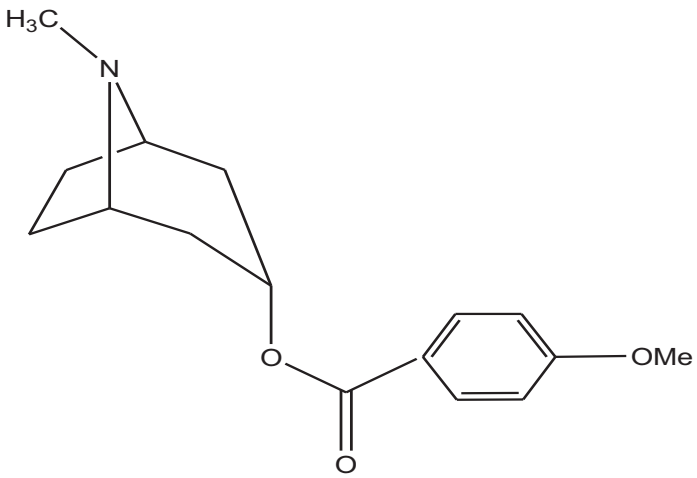


Figure 2. Datumetin (1).

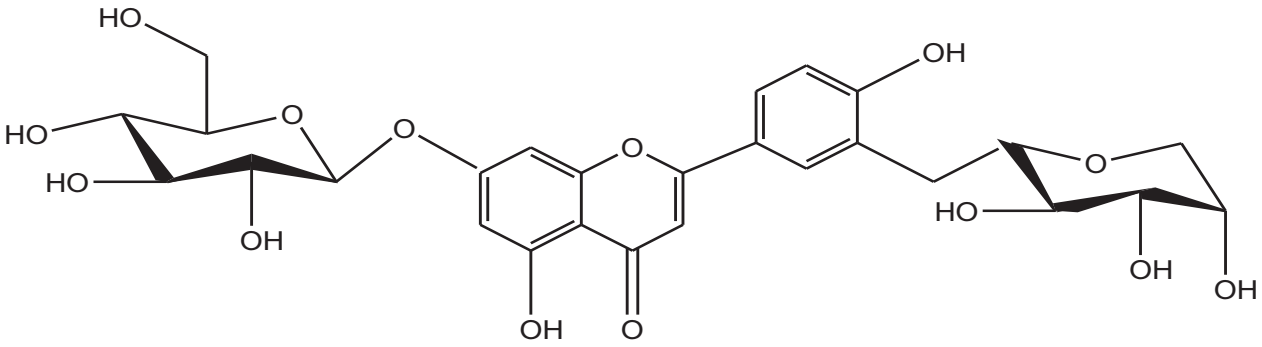


Figure 3. Kaempferol (2).

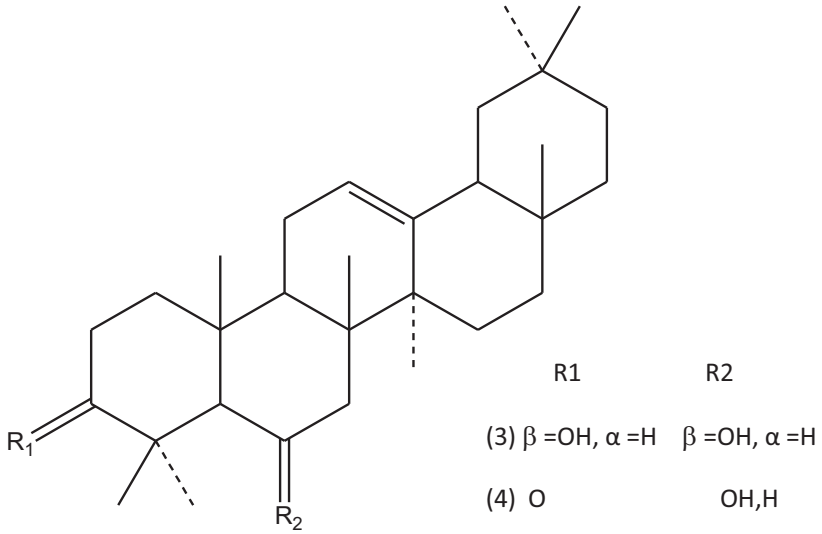
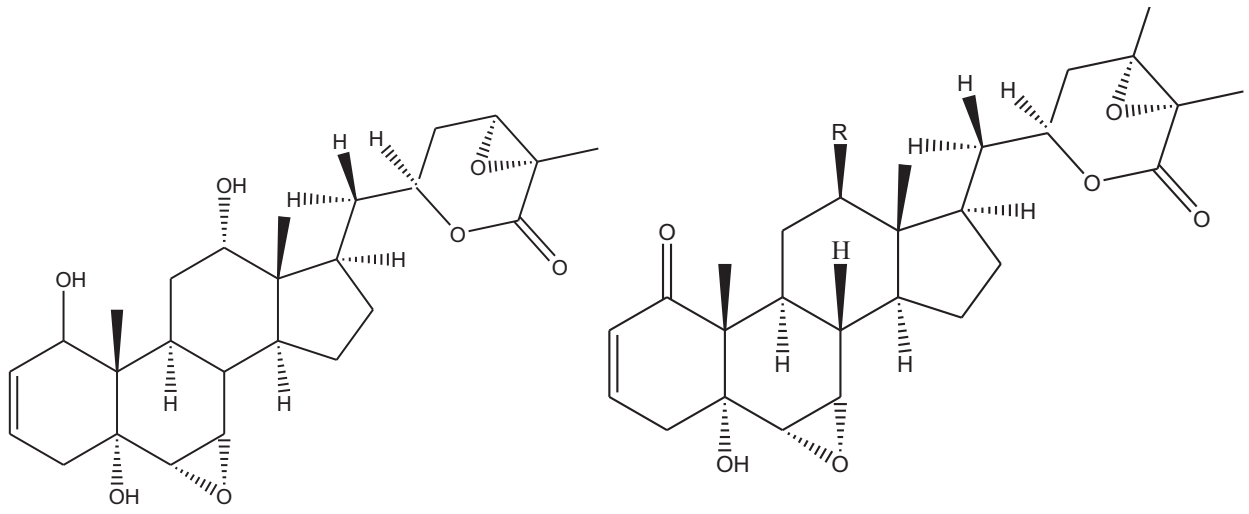
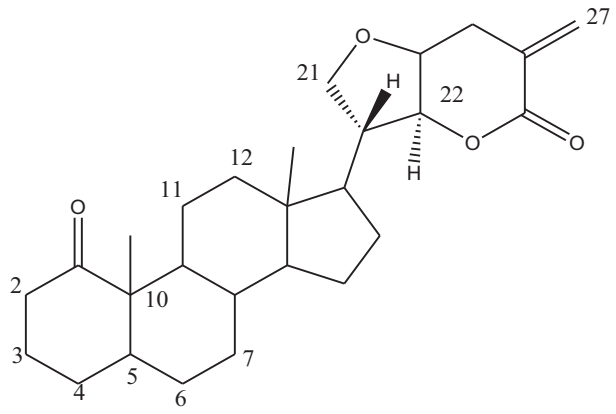


Figure 4. (a) Daturadiol (3); (b) Daturaolone (4).



(5) (6) R = O (7) R = OH

Figure 5. Daturalactone.



8 = Δ^2, 5β, 6β–epoxy, OH-12β

9 = Δ^2, 5α–OH, OH-6β , OH-12β

10= $\Delta^{2,4}$, OH-6β , OH-12β

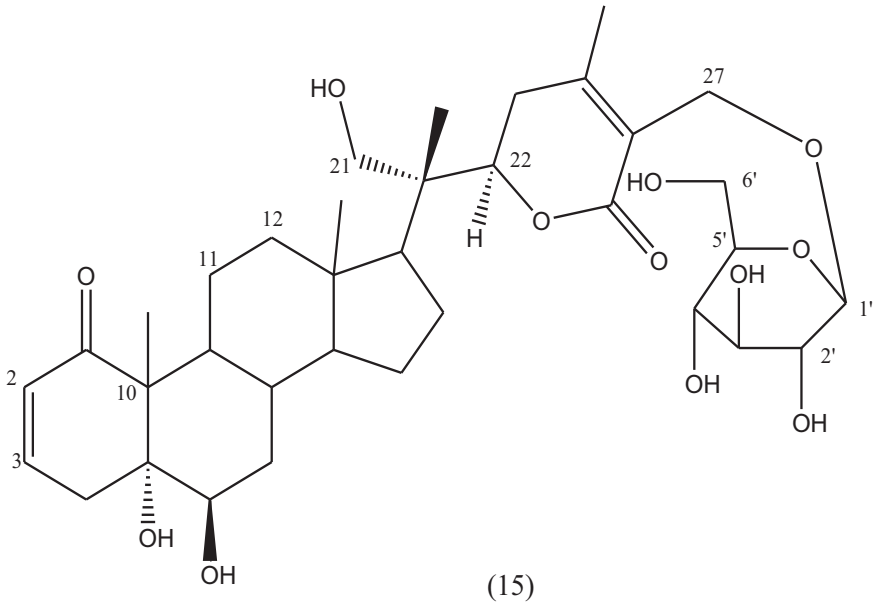
11= $\Delta^{2,5}$, OH-12β

12= $\Delta^{3,5}$, OH-12β

13=3α–OH, 5β , 6β–epoxy

14= Δ^2, OH-5β , OH-6α

Figure 6. Withametelins.



(15)

Figure 7. 1,10 seco withametelins.

than the standard drug.

A concoction brewed from *D. stramonium*, *Calotropis gigantean, Azadirachta indica* and cow manure was used against floral malformations caused by *Fusarium mangiferae* (Usha et al., 2009). The study proved that the concoction 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 Aqueous extract of *D. alba Rees* was evaluated against *Rumex dentalus L*., a problematic weed of wheat. Application of aqueous extracts caused 68% reduction in germination, 62% in shoot length, 96% in root length and 68% in seedling biomass (Jamid et al., 2009).

Scopalamine has been shown to attenuate memory task. Grasby et al. (1993) have suggested that the acute blockade of cholinergic neurotransmission effects diverse brain areas, including components of visual and motor systems and in addition modulates memory task activation at distinct points in distributed network for memory function.

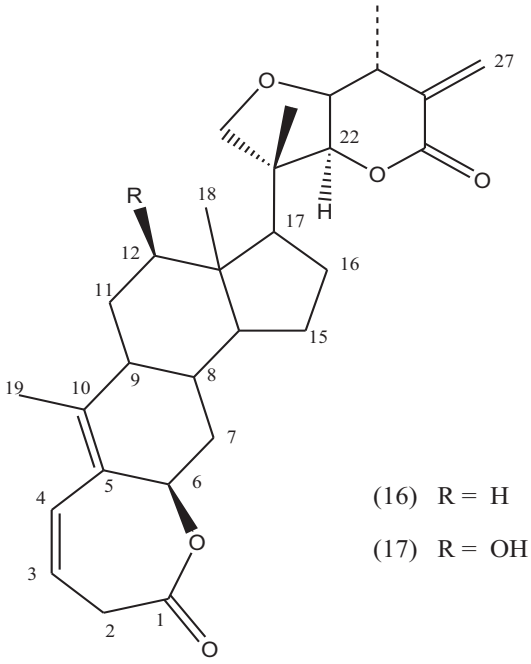


Figure 8. 12 β hydroxyl -1,10 seco withametelins.

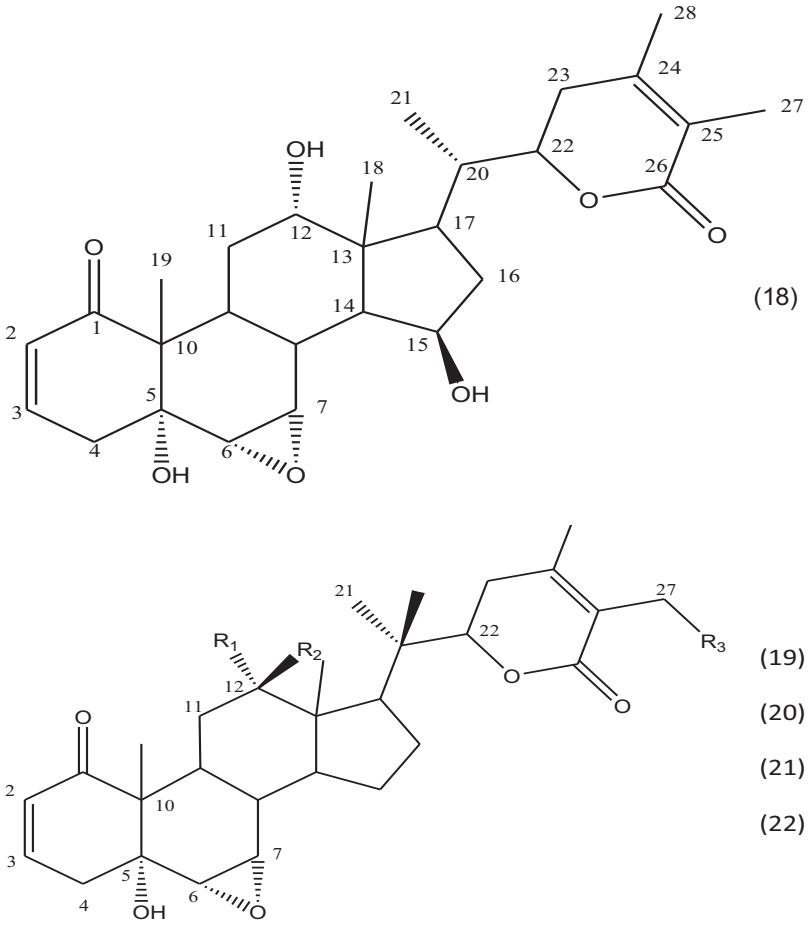
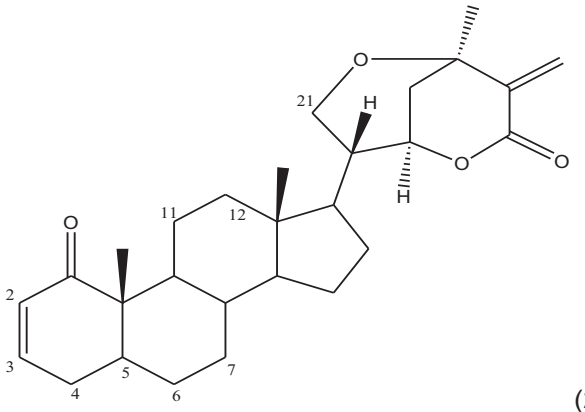
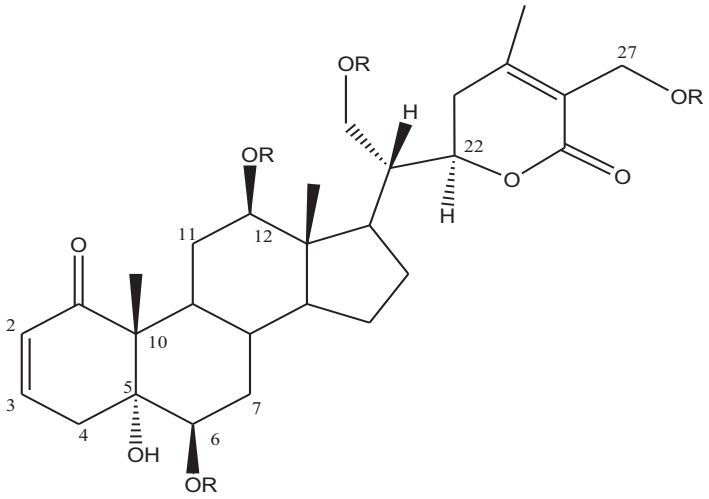


Figure 9. Withametelin E.

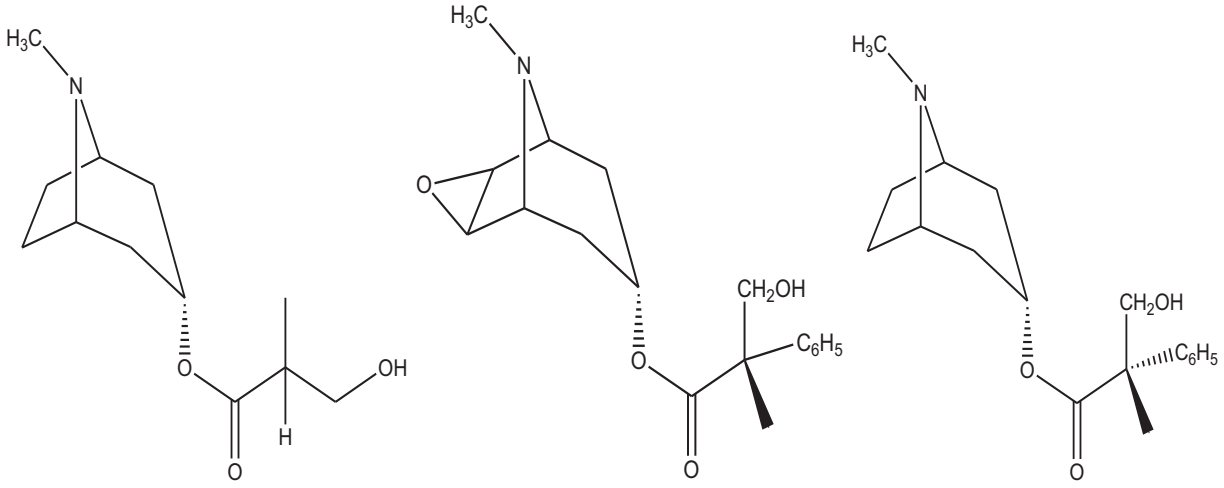


(23)



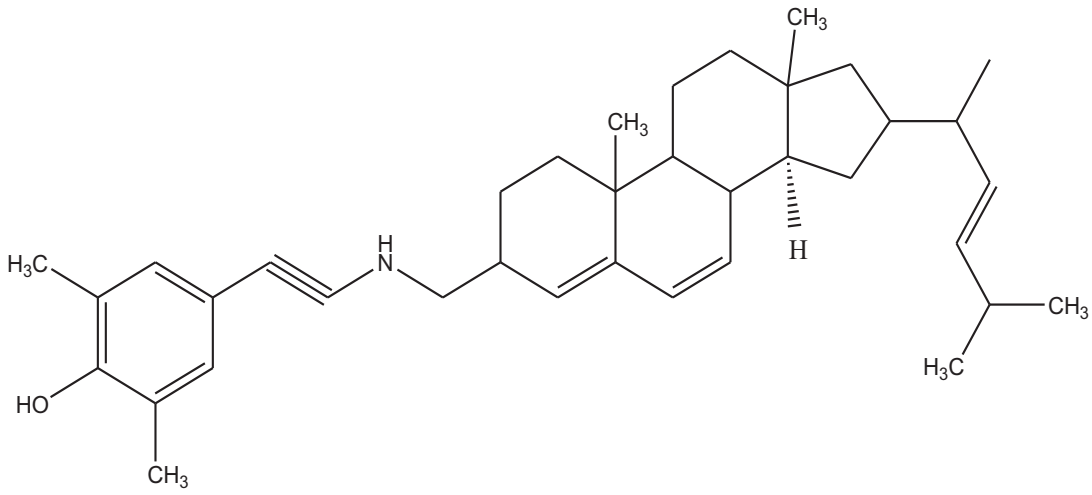
(24)

Figure 10. Withatatulin.



(25) (26) (27)

Figure 11. (25) Atropine; (26) Scopolamine; (27) (-)- Hyoscyamine.



(28)

Figure 12. 5', 7' dimethyl 6'-hydroxy 3', phenyl 3 α-amine β-yne sitosterol.

CONCLUSION

Medicinal plants have formed the basis of health care throughout the world since the earliest days of humanity and are still widely used and have considerable importance in international trade. Plants are important for pharmacological research and drug development, not only when bioactive phytocompounds are used directly as therapeutic agents, but also as starting materials for the synthesis of drugs or as models for pharmacologically active compounds.

With latest advances in medicinal chemistry and knowledge of biosynthetic route for the development of lead compounds have opened a new perspectives in the field of drug chemistry. There is a need to design new molecules from natural sources to combat lethal diseases. Thus plants are prove as potential source for drug discovery. Withanolides have known anti cancer activity which needs to be further explored. However, the integration of herbal medicine into modern medicinal practises, including treatments for infections and cancer, must contemplate the related
issues of quality, safety and efficacy.

This review has been directed towards various interesting findings of the medicinal value of *Datura*, apart from its toxicity and ornamental importance to prove it as a potent chemotherapeutic agent. Thus concerted efforts in the relevant areas is still necessary to establish rational and sustainable exploitation of the worlds biodiversity.

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