Available online on 25.03.2022 at http://jddtonline.info

Journal of Drug Delivery and Therapeutics

Open Access to Pharmaceutical and Medical Research

Open Access Full Text Article

Review Article

An updated ethnobotany, phytochemical and pharmacological potential of *Solanum indicum* L.

Murteza Iqubal[1]*, Satish Kumar Sharma[1], Mohd. Mujahid [2], Md. Sarfaraj Hussain[3],

[1] Department of Pharmacognosy & Phytochemistry, School of Pharmacy, Glocal University, Delhi Yamunotri Marg, Mirzapur Pole District- Saharanpur, U.P. India. 247121

[2] Department of Pharmacy Practice, College of Pharmacy, Hafr Al Batin University, Hafr- Al Batin, Saudi Arabia

[3] Lord Buddha Koshi College of Pharmacy, Baijanathpur, Saharsa, 852201, Bihar, India

Article Info:

Article History:

Received 02 February 2022
Reviewed 27 February 2022
Accepted 06 March 2022
Published 25 March 2022

Cite this article as:

Iqubal M, Sharma SK, Mujahid M, Hussain MS, An updated ethnobotany, phytochemical and pharmacological potential of *Solanum indicum* L. , Journal of Drug Delivery and Therapeutics. 2022; 12(2):160-172

DOI: http://dx.doi.org/10.22270/jddt.v12i2.5385

*Address for Correspondence:

Murteza Iqubal, Research Scholar, Department of Pharmacognosy & Phytochemistry, School of Pharmacy, Delhi Yamunotri Marg, Mirzapur Pole District- Saharanpur, U.P. India. 247121.

ORCID ID: *https://orcid.org/0000-0002-6875-9182*

Abstract

Solanum indicum L. (Family Solanaceae), also known as poison berry in English, is a thorny, heavily branched perennial under shrub that can grow up to 1 metre in height and reach heights of up to 1 metre in height. This wonderful medicinal plant is extensively used in folk and traditional Indian systems of medicine to treat toxic affections, skin problems, ulcers, difficulties breathing, stomach aches, coughing, and dyspepsia, among other conditions. It is native to India and can be found throughout the country, primarily in warmer climates up to an elevation of 1500 metres. It is a well-known Indian medicinal plant that has been utilised extensively in the Ayurvedic system of medicine of treatment for many years in various ailments. It is a key component of the dasamoola group of plants' composition. Solasodine, Solasonine, Solamargine, Solanidine, and Solanine are some of the active steroidal alkaloids/glycoalkaloids found in *S. indicum*. The presence of various phytoconstituents in the plant has been documented, including steroidal saponins, sesquiterpenoids, hydroxycoumarins, phenolic compounds, coumarins, coumarinolignoids alkaloids, saponin, fatty acids, glycerides of the oil, and triterpenes, among other substances. Various pharmacological effects of the plant, including antibacterial, antioxidant, anthelmintic, antiplasmodial, hepatoprotective, anticancer, laxative, cardiotonic activity, CNS depressant and anti-hypertensive, hepatoprotective qualities, have been discovered in the plant. So, the aim of the present review is to provide comprehensive information from recognized sources on the ethnobotany, traditional uses, phytochemistry and pharmacological efficacy and of the medicinal plant, *S. indicum*. These reports are very encouraging and indicate that herb should be studied more extensively for its therapeutic benefits. Clinical trials using Solanum for a variety of combinations in different formulations should also be conducted.

Keywords: *Solanum indicum*, Solanaceae, ethnobotany, phytochemistry, phytopharmacology.

INTRODUCTION

Although modern scientific medicine has made significant advances in recent years, traditional medicine continues to be the primary method of treating diseases for the vast majority of people in developing countries, including India. Even among those who have access to western medicine, the number of people who use complementary or alternative medicine is rapidly increasing around the world. The growing understanding of metabolic processes and the effects of plants on human physiology has broadened the scope of medicinal plants' potential use in medicine[1]. The oldest evidence we know of human beings employing plants for medicinal purposes has been unable to be identified. Whether unintentionally or purposefully, it seems probable that man has been experimenting with nature for some time. For the most part, regular people were responsible for accumulating most of the collected information about valuable plants. However, when one is aware of the medical applications that thousands of wild plants around us have developed, the plant takes on a new significance, a new value that surpasses its aesthetic worth, its cooling shade, or its pleasant aroma [2, 3]. Nature has always been a first-rate medication shop, thanks to its great variety of plants that have been shown to offer medicinal properties that are effective. Traditional civilizations have amassed a wealth of information about herbal medicines via trial and error through hundreds of years of experience. Even more importantly, the most significant remedies were handed down orally from one generation to the next [4, 5]. Natural alternatives to synthetic chemicals, such as medicinal plants and plant-derived medications, have long been practised in civilizations all over the globe, and they are becoming more popular in contemporary society as natural alternatives to synthetic chemicals. Quinine, morphine, codeine, atropine, reserpine, and digoxin are all examples of plant-derived medications that are widely used today [6-8]. It is an unassailable truth that plants are the world's largest laboratory for naturally occurring components. Plant medications have had a significant resurgence in recent years. For one thing, researchers started to extract and identify the ingredients and active elements of medicinal plants, which led to the discovery of new drugs [9, 10]. Traditional medicine has a very long history; it is the sum total of practises based on the theories, beliefs, and experiences of different cultures and time periods, which are often inexplicable, and which are used in the maintenance of health as well as the prevention, diagnosis, improvement, and treatment of illness. Traditional medicine has a very long history; it is the sum total of practises based on the theories, beliefs, and experiences of different cultures and time periods, which are often inexplicable [11, 12]. The majority of people who have taken traditional medicines may not comprehend the scientific logic for the cures, but they seem to be aware from personal experience that certain medicinal herbs may be quite effective when used at therapeutic quantities. Since we have gained a greater knowledge of how the body operates over the centuries, we are in a better position to appreciate the healing properties of plants and their potential as multi-functional chemical entities for addressing complex health issues than we were before [13, 14].

Solanum indicum (also known as *Solanum violaceum* Ortega or *Solanum anguivi* Lam.) is a medicinal plant that is utilised in Indian medical systems such as Ayurveda, Siddha, and Unani to treat a variety of ailments. It is a significant component of the dasamoola (a set of 10 root medications) group of plants in Ayurvedic and Siddha medicine, and it is used to treat vitiated diseases of the vata, pita, and kapha doshas, as well as a variety of other disorders. It is used to cure nausea and vomiting, heart illness, toxic affections, skin diseases, ulcers, trouble breathing, stomach discomfort, coughing, and dyspepsia, among other things. It is also used to treat other conditions. Despite their appearance, the roots have a harsh and bitter flavour. It removes the nasty taste from the month as well as the lack of desire for food [15]. However, the root is the most often used medicinal component of the plant, with the fruits and leaves also being used seldom, as is the whole plant as a whole. The root is a significant component in around 68 distinct Ayurvedic formulations. It may be used either as a stand-alone herb or as a component of the dasamoola group of plants, depending on the application. In several significant formulations, such as Amritharishtam and Gandha Taila, it is used; others include Balajeerakadi Kashaya, Manasamithra Vataka, Pippalyadi Gridha, Rajanyadi Choorna, and Vidaryadi Gridha, among others. Amritharishtam is a kind of Ayurvedic medication that is used to treat various ailments. It is a perennial under shrub with numerous branches that has prickles on the tips of the leaves. The plant may be found mostly in warmer regions of the country, up to a height of 1500 metres above sea level [16-23]. The plant is a densely branched, widely distributed, and exceedingly thorny under shrub that grows to a height of 0.3-1m. Its leaves are simple, big and oval, sub-entire, sinuate, or lobed, sparsely prickly on both sides, with a cordate base that is frequently uneven in size. The flowers are blue and borne in axillary cymes that are stellately hairy, and the peduncles are stellately hairy as well. The plant, according to Acharya Charaka, belongs to the Kanthya (group of herbs used in treating throat disorders), Hikkanigrahana (group of herbs used in treating hiccups), Shothahara (anti-inflammatory group of herbs), and Angamarda Prashamana (pain relieving group of herbs) mahakashyas, whereas the plant, according to Acharya Susuruta, belongs to the Laghupanchmula [24-26].

MATERIALS AND METHODS

This review paper included information on ethnobotanical descriptions, plant components, and biological impacts, among other things. There was additional material about M. oleifera that could be obtained in a peer-reviewed publication, which was included in the package. A comprehensive search of online databases such as ACS Publications and Elsevier was conducted in order to locate the proper material for this project. We also had a look over the books in the library with our group. Some of the terms used to obtain information on the plant were "*Solanum*," "*S. indicum*," "traditional uses of *S. indicum*," "ethnobotany," "phytochemistry," "biological activities," Indian herbal classic books, and a Ph.D. dissertation. Prior to January 2021, only English-language publications were considered for inclusion on the list. Non-English language articles, previously unpublished data, and publications that were not original were not included in the selection process. Using the The Plant List website, www.theplantlist.org, the scientific name for the plant was determined.

BOTANICAL DESCRIPTION

Distribution

This species may be found in tropical India, Sri Lanka, Malaya, China, and the Philippines, among other places. It may be found in a variety of habitats across India's tropical areas, including waste fields, roadside ditches, and other locations, ranging from sea level to around 1500 m above sea level [27].

Morphological Characters *S. indicum*

A biennial, upright, spiky herb or small shrub with sturdy stems, huge, sharp prickles with a long compressed base that is typically somewhat recurved, and prickles that are large and sharp. Plant has leaves that are 5-15 cm long and 2.5-7.5 cm broad, oblong in form, sub-entire with a few triangular-oval lobes, sparsely prickly and hairy on both sides; the base is cordate or truncate, frequently uneven sided; the petioles are 1.3-2.5 cm long and hairy on both sides. Flowers are borne in racemose extra axillary cymes, with short, stellately-hairy peduncles; the corolla is pale purple, 0.8 cm long, and covered with darker purple stellate hair on the outside; the lobes are 5 mm long; the stamens are attached to the corolla, with filaments that are short and anthers that are large. Fruits (berries) are globose, approximately 0.8 cm in diameter when ripe, and glabrous. When ripe, they are dark yellow. Seeds are 0.4 cm in diameter and have minute pits. In Central and Southern India, flowering and fruiting are often seen between August and October, with fruting occurring between November and December [27-30]. Figure 1 depicts the many components of the plant.

Figure 1: Exomorphic features of *Solanum indicum Linn.*

Traditional applications

Both the root and the fruit have a strong and bitter flavour. According to Ayurvedic systems of medicine, they are warming, digestive, astringent to the bowels, anthelmintic, removes foulness from the mouth, beneficial in cardiac troubles, useful in leucoderma, fever, asthma, pain bronchitis, vomiting, and pruritus. They are also beneficial in a variety of other conditions. The roots are beneficial in the treatment of vitiated vata and kapha conditions, as well as odontalgia, dyspepsia, flatulence, colic, verminosis, diarrhoea, leprosy, strangury, cough, asthma, fever, skin diseases, respiratory and cardiac disorders, ulcers, and poisonous affections, among other things. The root is used in difficult parturition as well as in the treatment of toothache. It is also used in the treatment of fevers, worm problems, and colic. It is considered an expectorant and is beneficial in the treatment of cough and catarrhal diseases. In the event of dysuria and inchuria, it is recommended to be taken [15-17, 27, 31].

Classical application

In traditional systems of treatment such as Ayurveda, *S. indicum* fruits are cooked and seasoned before being mixed with boiled curd and administered to patients suffering from anorexia (Vaidyamanorama). Alopecia areata may be cured by applying the juice of fruit combined with honey to the affected area (Vrndhamadhava; Gadanigraha; Sarngadharasamhita). The juice of brhati fruits is used to crushed the fruit and root of gunja, which is then rubbed with Datura fruit. It takes away the opacity (Vrndhamadhava). An inhalation of powdered *S. indicum* fruit and ginger mixed together is administered via the nose. The patient sneezes and regains consciousness as a result of this (Gadanigraha). Fruit is softly streamed in water, pulverised, and cooked in ghee until soft and fragrant. Then it's mixed with powdered rock salt before being consumed. It helps to improve digestion while also alleviating coughing (Kalyanakaraka). Pipalyadileha has a component called brhati fruit (Gadanigraha). After removing the seeds from the maturing fruit of brhati, a paste of pipali and srotonjana is used to fill the fruit. Once the paste has been set for a week, it is removed and put to the eyes as collyrium. The similar technique is followed in the case of the fruits sigru, indravaruni, patola, kiratatikta, and amalaka, which are used to treat eye ailments (Susrutha-samhita Utharastana). Fumigation of the ear canal with varttakadistroyes maggots (Charaka-samhita Cikitsasthanam). A mixture of kantakari and brhati fruit juices, as well as panchakola, honey, and ghee, should be given to a youngster who regularly refuses breast milk (Ashtangahridaya Utharastanam). The combination of brhati and butter milk is effective in treating grahani disease. Brhati fruit is cooked in alkaline water from kosataki and fried in ghee to make a delectable dish. It is consumed with jaggery until fully satisfied, after which it is followed by the consumption of butter milk. It completely eliminates haemorrhoids within a week. Sushruta, Charaka, and Vagbhata all recommend the root and fruit for snake bites and scorpion stings (Charaka, Vagbhata, Yogaratnakara, Rasaratnakara) respectively [32-33].

Ethnomedical Uses

This plant is used in traditional Chinese medicine as a heart tonic, as an astringent, as a carminative, as an immunomodulator, and in clinical medicine to treat weakness, nausea, and bronchospasm [34]. *S. indicum* fruits are known to stimulate and strengthen the heart, as well as to alleviate edoema. It is also effective in the treatment of dysuria and urinary calculi [35]. In Bangladesh's Dhamrai Sub-district, in the Dhaka District, crushed leaves combined with water are consumed to treat hypertension and are also given topically to bite wounds [36]. The Santal Tribe of Bangladesh, who live in Thakurgaon District, combine the bark from the root of *S. indicum* with the bark of *Alstonia scholaris* to treat debility [37]. The unripe fruits are cooked and consumed with meals by the tribal people of Irulas in the Hasanur Hills, a region of the Southern Western Ghats, in order to expel tapeworms. Oraon tribal communities in the state of Jharkhand's Latehar district, who have a significant amount of traditional knowledge of edible weeds from crop fields and edible wild plants from forests and hills, are preparing the fruits of *S. indicum* as a vegetable after boiling them in water and draining the excess water. Fruit and leaves that have been cooked in curries or roasted have been shown to be beneficial as blood purifiers [38]. Chronic sinusitis, migraine, asthma, and headache are all treated with the use of leaves as well [39, 40]. In the treatment of kidney stone and urinary tract infection, root powder of *S. indicum* combined with *S. surattense* is administered with curd for two weeks [41]. *S. indicum* is used to alleviate the symptoms of flatulence and intestinal colic, as well as in the treatment of asthma. Root of *S. indicum* is employed for Aphrodisiac Potentials in Rajasthani folklore and traditional medicine [42]. Unripe fruits of the *S. indicum* plant are cooked and consumed with meals in the Ariyalur District of Tamil Nadu in order to expel tapeworms. These fruits are used to make pickles and are also beneficial in the treatment of digestive disorders [43]. In Arunachal Pradesh, *S. indicum* is used as a vegetable (green salad) to treat intestinal parasitic worms such as round and tape worms, and the leaves of *S. indicum* are used as common growth supplements during the preparation of fermentation starter cultures containing brewer's yeast. *S. indicum* is also used to treat intestinal parasitic worms such as round and tape worms [44]. Fruits of the *S. indicum* tree are used as food in Assam and Thailand [45]. Medicinal uses for *S. indicum* include usage as vegetables and as a key element in anticarcinogen formulations in Thailand [46]. Throughout Taiwan, *S. indicum* L. is used as a folk medicine to treat toothache, ascites, edoema, and wound infection, among other ailments. The fruit is used to treat leukoderma, pruritus, and bronchitis, and the juice extracted from the leaves is used with fresh ginger juice to alleviate nausea and vomiting [47]. This plant, which grows in the south of China, has been used in Chinese traditional medicine as an analgesic for toothache, rhinitis, and breast cancer pain. It is also used to treat wounds and promote wound healing (Table 2) [48].

Phytochemistry

Many phytoconstituents, including phytosterols, steroidal glycosides, steroidal glycoalkaloids, flavonoids, and fatty acids, have been extracted from plants and have been shown to be active chemicals in animal and human studies. Its crude fibre content is 8 percent wet weight, and its total carbohydrate content is 40.67 percent wet weight. Its crude protein content is 23.47 percent wet weight, and its total ash content is 22.66 percent wet weight. Its crude fat content is 5.26 percent wet weight, and its caloric content is 526 calories per 100 gm wet weight (303.9 wet weight). This includes testing for the presence of alkaloids, polyphenols (7.02mg/g), and saponins among other things. Steroid glycosides and steroidal glycoalkaloid constituents of plants are the most often encountered of all of their constituents, and they account for the majority of their occurrences. The overall alkaloids content varies depending on the type of fruit, ranging from 0.2 to 1.8 percent, whereas the total alkaloids concentration in the leaves is 0.32 percent of the total (dry weight basis) [27, 32].

Steroidal alkaloids/glycoalkaloids

Steroidal alkaloids are a substantial family of secondary metabolites that are of great interest from both an ecological and a human health viewpoint, and they have been widely investigated in both the laboratory and the field. Throughout the Genus Solanum, these alkaloids may be found in high concentrations, with the highest concentrations being found in the flowering parts of the plant (flowering buds), sprouting leaves, unripe berries, immature leaves, and young shoots. These compounds are made up of two structural components: the first aglycone unit contains the basic steroidal 27-carbon skeleton (cyclopentanophenanthrene) of cholestane with nitrogen incorporated into the F ring, which is amiphiphilic in nature; and the second aglycone unit contains the basic steroidal 27-carbon skeleton (cyclopentanophenanthrene) of cholestane with nitrogen incorporated into the For the second time, a hydrophilic glycone unit is attached to the 3-OH position of the molecule (Figure 2). This family of substances is classed as pseudoalkaloids, which is a subclass of alkaloids, owing to the introduction of nitrogen into a nonamino acid residue in the chemical structure (or isoprenoid alkaloids). Steroid glycoalkaloids are generally divided into two groups based on the presence or absence of an aglycone part of their structure. Solasodine is an example of the spirosolan type; the solanidane type is an example of the solanidane type, in which N links the spirostan rings E and F rings, as is the case with solanidine. Solasodine, solanidine, solasonine, solamargine, and solanine were all discovered in S. indicum, as was solanidine. It has been discovered that the plant contains several phytoconstituents such as carotene, carpesterol, solanocarpone, diosgenin, -sitosterol, lanosterol, solavetivone, solafuranone, scopoletin N-(ptranscoumaroyl) tyramine, and indiosides (Table 1) [27, 32, 49].

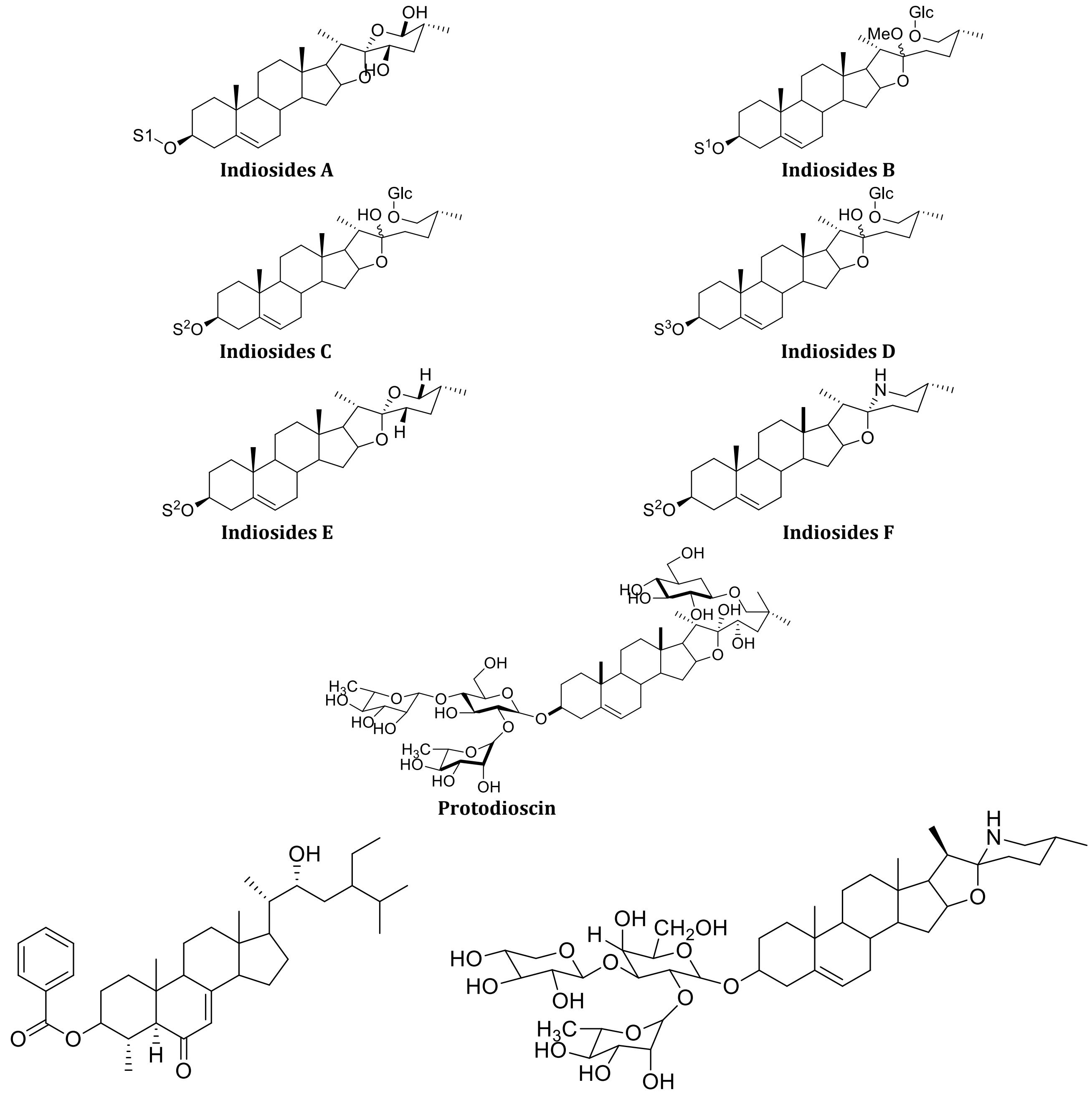
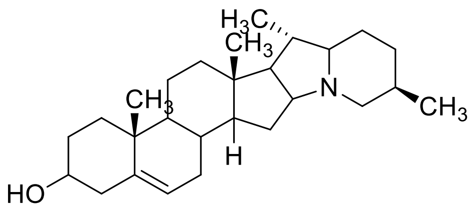
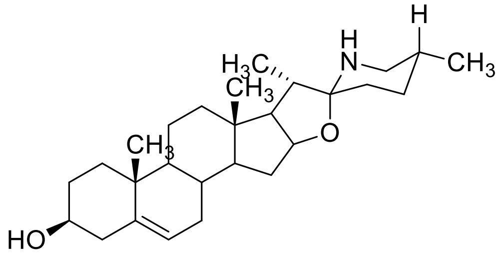


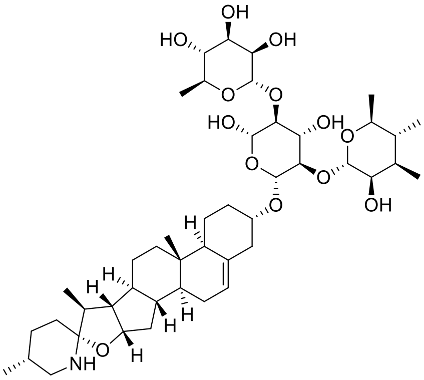
Figure 2(a): Previously isolated phytoconstuents of *Solanum indicum Linn.*



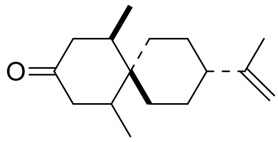
Solanidine



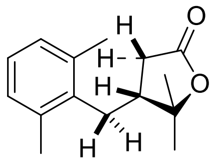
Solasodine



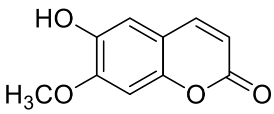
Solamargine



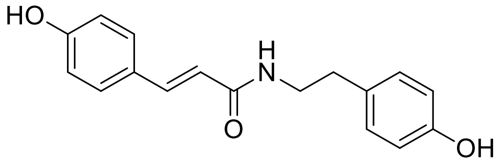
Solavetivone



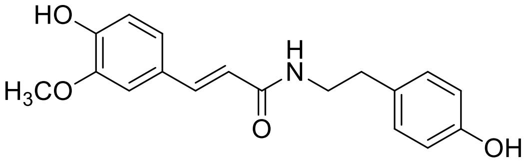
Solafuranone



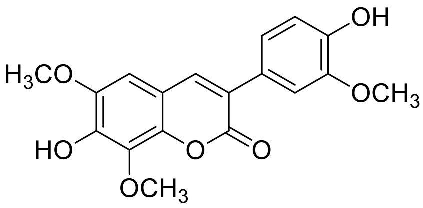
Scopoletin



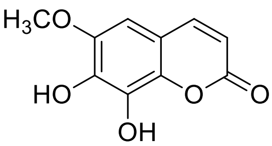
N-p-trans-Coumaroyltyramine



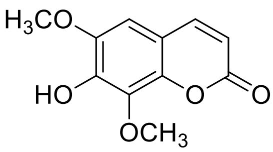
N-Trans-Feruloyltyramine



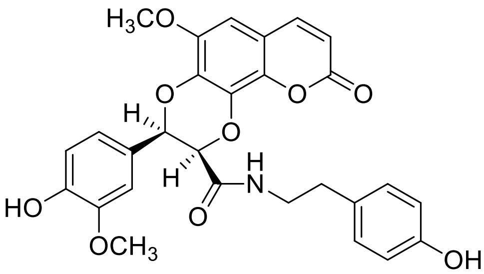
7-Hydroxy-6,8-Dimethoxy-3-(40-Hydroxy-30-Methoxyphenyl)-Coumarin



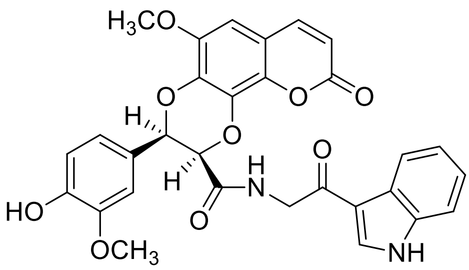
Isofraxidin



Fraxetin

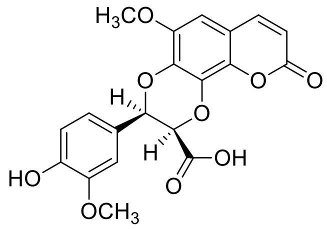


Indicumine A

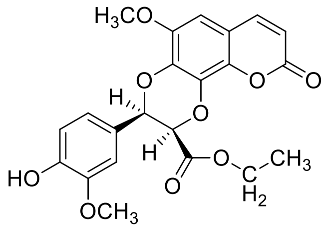


Indicumin B

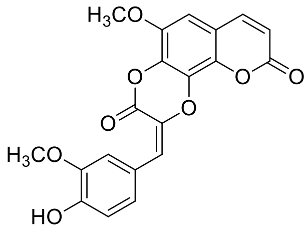
Figure 2(b): Previously isolated phytoconstuents of *Solanum indicum Linn.*



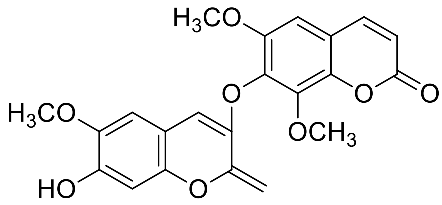
Indicumine C



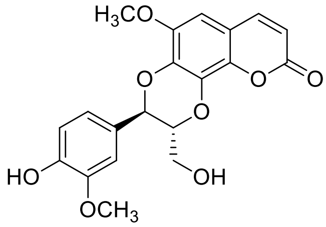
Indicumin D



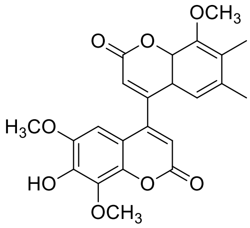
Indicumine E



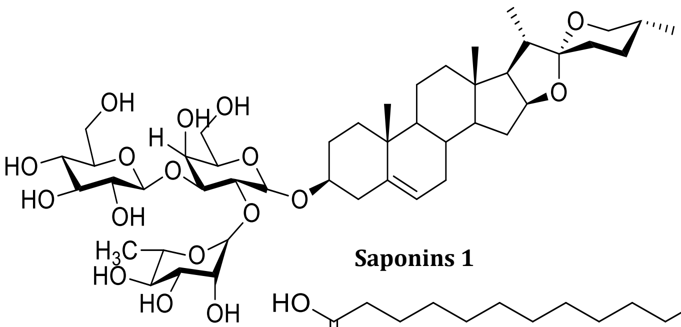
Arteminorin



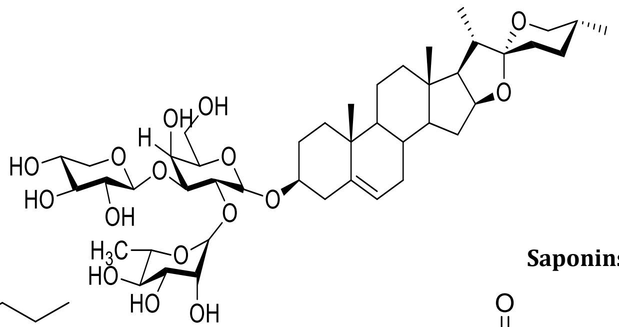
Cleosandrin



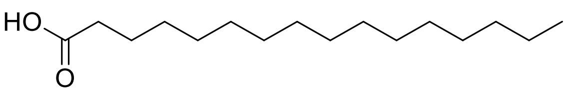
4, 4’-biisofraxidin

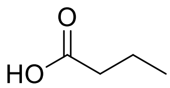


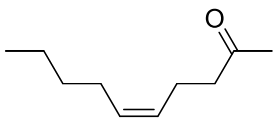
Saponins 1



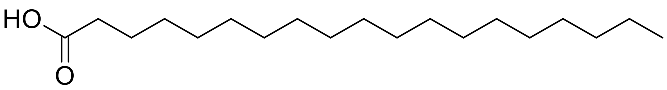
Saponins 2

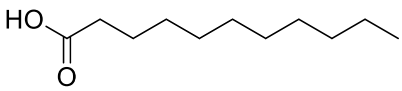




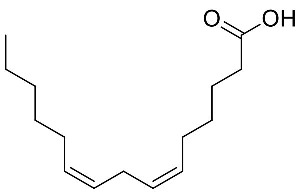


Palmitic acid **Stearic acid** **Arachidic acid**

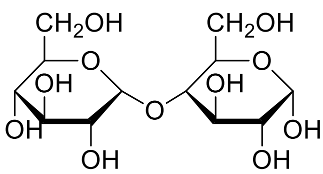




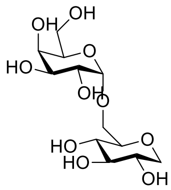
Oleic acid **Linoleic acid**



Lauric Acid

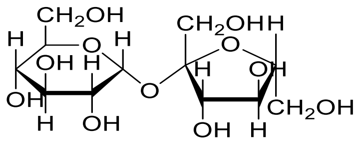


Maltose

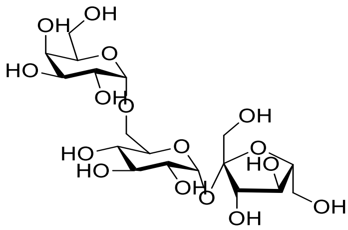


Melibiose

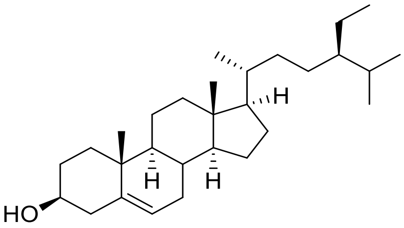
Figure 2(c): Previously isolated phytoconstuents of *Solanum indicum Linn.*



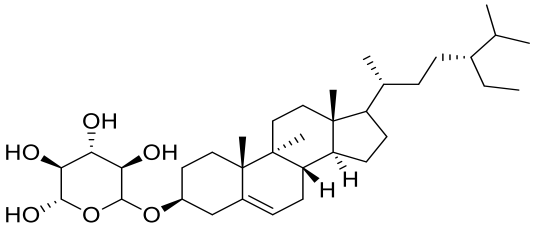
Sucrose



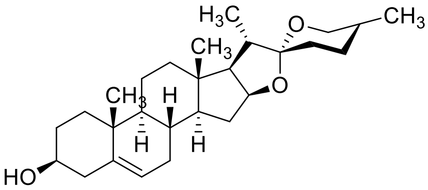
Raffinose



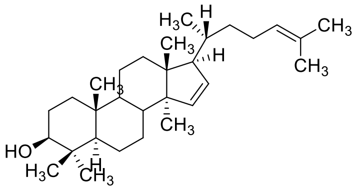
β-Sitosterol



Daucosterol



Diosgenin



Lanosterol

Figure 2(d): Previously isolated phytoconstuents of *Solanum indicum Linn.*

Table 1: Phytochemical work reported on *Solanum indicum Linn.*

Plant part	Identified Constituents	References
Fruits	Indioside A	73
	Indioside B	73
	Fatty acids	74, 75
Roots	Solanine	74, 75
	Solanidine	74, 75
	Indioside C	73
	Indioside D	74, 75
	Indioside E	73
	Solamargine	73
	Solasonine	73
	Isoanguivine	73
Leaves	Solanine	74, 75, 76
	Solanidine	74, 75, 76
Whole Plant	Dioscin	63, 77
	Methyl-protodioscin	63, 77
	β-sitosterol	63, 77
	β-sitosterol glucoside	63, 77
	Protodioscin	63, 77
	Methyl protodioscin	63, 77
	Scopoletin	62, 78
	Solafurone	62, 78

PHYTOPHARMACOLOGICAL ACTIVITIES

The following are some of the folk and traditional applications of the plant; it has also been studied scientifically in animal models to see whether or not the plant has the ability to treat a number of maladies.

Table 2: Traditional Uses of *Solanum indicum Linn.*

S.No.	Plant parts	Uses quoted in Literature	Ref
1.	Leaves	Juice of leaves with ginger stops vomitting.	79
		Rubbed with sugar, used as external application to relieve itch.	79, 80
2.	Fruits/Berries	Fruit juice beneficial in alopesia.	81
		Dried powder given to children to expel worms among tribes of Orissa.	81
		In cases of loss of appetite, bitter stomachic.	81
3.	Roots	Prescribed in cases of dysuria & inchuria.	82-84
		Pounded roots used for nasal ulcers.	82-84
		Facilitates child-birth.	82-84
		Employed in difficult parturition.	82-84
4.	Whole Plant	Antipyretic	85
		Beneficial in catarrhal affections, asthma, dry coughs, cardiac troubles, dropsy, relieves toothache, worm complaints, antidiarrhoeal & antiulcerogenic.	86, 87

Antibacterial activity

- A leaf ethanolic extract of *S. indicum* exhibited antibacterial efficacy against *Corynebacterium diptheriae*, *Pseudomonas spp*., and *Salmonella typhimorium*, as well as against other bacteria found that the chloroform extract was effective against *Staphylococcus aureus, Bacillus cereus*, and *Escherichia coli*, whereas the acetone extract and ethanol extract were effective against *Pseudomonas aeruginosa* [48, 50].
- The fruits of *S. indicum* are also known to have antimicrobial properties. *Listeria innocua, S. aureus, E. coli* and *P. aeruginosa* strains were tested, and it was discovered that both the aqueous and ethanolic extracts were efficient against the bacteria. According to the findings, the activity of the ethanolic extract was superior to that of the aqueous extract [51].
- The aqueous fraction of the ethanolic extract of *S. indicum* berries has been shown to have a concentration-dependent inhibitory impact on *P. aeruginosa, P. fluorescens*, and *P. syringae* strains, according to the findings. Flavonoids, carotenoids, and saponins were found in the examined aqueous fraction, according to the results [52].

Antioxidant activity

- The antioxidant activity of an ethnolic extract of berries from *S. indicum* was studied utilising an in vitro DPPH (1, 1-Diphenyl-2-Picryl hydrazyl radical) radical scavenging technique in order to determine its antioxidant activity. At a concentration of 200 g/mL, the extract exhibits the greatest amount of inhibition (70.007±0.841 percent) [53].
- IC_{50} values for the ethanolic and aqueous extracts of berries were computed using the DPPH Scavenging Assay and the -carotene/linoleate model system, according to the results of another work. It was shown that ethanolic extract was significantly more efficient (IC_{50} 37.22±1.3) in the alpha-carotene test, while aqueous extract was discovered to be more successful in the DPPH assay (IC_{50} 21.83 ±0.84) in both assays. This suggests that the fruit may serve as a useful source of natural antioxidants in the diet [54].
- N'Dri et al., 2010 [55] found that, when the antioxidant capacity of fruit is studied using the FRAP test and the Folin-Ciocalteau assay, it has been observed that the antioxidant potential rises as ripening occurs. It was possible that this was owing to the fact that the concentration of -carotene in red berries increased by 60 and 20 times, respectively, when compared to green and yellow berries. The amount of ascorbic acid found in green and yellow berries was found to be equal, however the amount found in red berries was found to be lower. The total polyphenol content did not change with ripening, but the concentrations of caffeoylquinic acids, caffeic acid, flavonol glycosides, and naringenin increased with maturity, while the concentrations of p-coumaric acid and feruloylquinic acids remained constant throughout the ripening process.
- The ethanolic extract of *S. indicum* berries also greatly reduced the generation of peroxides in a linoleic acid emulsion system in a dose-dependent manner, as shown by the results of this study [56].
- The aqueous and ethanolic extracts of the leaves of *S. indicum* have also been shown to have DPPH scavenging capability [57].

Anthelmintic activity

- The anthelminthic activity of butanol and aqueous fractions of methanolic extract of *S. indicum* fruits was determined utilising a *Caenorhabditis elegans* bioassay. After 24 hours of incubation, the percentage of dead nematodes was determined. Based on the results of the *C. elegans* experiment, fractions eluted from DEAE cellulose demonstrated anthelmintic activity in four distinct peaks. Those peaks were eluted at concentrations of 0.1, 0.28, 0.48, and 0.85 M NaCl, respectively. When compared to the negative control, the highest mean death percentages found at each peak were 53, 59, 37, and 61 percent, respectively. SI fruit seems to have at least four separate anthelmintic chemicals, according to the research [58].
- In a study conducted on the Indian earthworm (*Pheretima posthuma*), it was discovered that a crude methanolic extract of *S. indicum* berries (100 mg/mL) paralysed the worm in 9.16 ± 0.12 seconds, while the helminth died in 17.71 ± 0.21 seconds [53].

Antiinflammatory Effect

In one set of experiments, oral dosages of an extract of the root of *Solanum indicum* were administered 60 minutes before the injection of carrageenin was administered. The paw volume grew by 78 percent in the negative control carrageenin group, whereas the paw volume increased by 35 percent in the normal phenylbutazone group. Paw volumes were lower in all dosages of the *Solanum indicum* extract than in the negative control group, but greater than in the phenylbutazone group when compared to the negative control. In another experiment, the fruit extract of *Solanum indicum* (Indian gooseberry) was used. There was no difference in paw volume between the negative control group and the standard phenylbutazone group when all dosages of *Solanum indicum* fruit extract were administered [59].

Antiplasmodial activity

It was determined that the antiplasmodial activity of ethanolic fruit extract against the chloroquine-resistant FcB1 strain of Plasmodium falciparum was in vitro when it was tested. The cytotoxicity of the compound was tested on the human MRC-5 (IC50 >50g/mL) and rat L-6 cell lines (IC50 >50g/mL) cell lines. Plant extracts shown substantial antimalarial action (IC50 = 41.3 ± 7.0 g/Ml) when tested against parasites [60].

Hepatoprotective activity

- The hepatoprotective profile of *Solanum indicum* Linn fruit extract, in a 10 percent suspension stabilised with 1 percent acacia gum, was evaluated in male Wistar rats by exposing them to a single dosage of paracetamol suspended in a 40 percent sucrose solution and observing their responses. After the experiment was completed, the animals were slaughtered and blood and liver samples were obtained for biochemical and histological investigations. The research demonstrated that, despite the fact that there was no indication of a hepatoprotective effect, liver enzymes, which indicate the level of liver damage, were lowered by eighteen percent when compared to the paracetamol control group when *S. indicum* therapy was administered [61].
- The effects of *S. indicum* extract (200 mg/kg) were investigated in a rat CCl4-induced hepatotoxicity model. Rats were studied to determine the levels of liver markers such as Alanine amino transferase (ALT), Aspartate amino transferase (AST), alkaline phosphatase (ALP), acid phosphatase (ACP), and lactate dehydrogenase (LDH), as well as certain biochemical parameters such as total protein, total bilirubin, total cholesterol, triglycerides, and urea. The plant extract has been shown to considerably reduce the harm caused by CCl_4 [56].

Anticancer activity

- Numerous Indiosides (A to E) isolated from *S. indicum* have been shown to have a dose-dependent inhibitory impact on the proliferation of Bel-7402 cells, as well as the ability to trigger cell death through the mitochondrial route. The compound solavetivone-1, which is found in *S. indicum*, was shown to be cytotoxic to OVCAR-3 cells [62].
- *S. indicum* (whole plant) chloroform soluble and insoluble fractions of the ethanolic extract were tested for anticancer activity using in-vitro techniques on seven cancer cell lines: Colo-205 (colon), KB (nasopharynx), HeLa (uterine cervix), Hep-2 (laryngeal epidermoid), GBM8401/TSGH (glioma) and H1477 (colon) (melanoma). By using the DEA and MTT assays, the purified components dioscin and methyl protodioscin were shown to have more powerful effects. In addition, dioscin, methyl protoprosapogenin A of dioscin, methyl protodioscin, and protodioscin were all found to have cytotoxic effects on cultured C6 glioma cells when tested in the PRE assay, and methyl protoprosapogenin A of dioscin, methyl protodioscin, and protodioscin were found to have a tumour Furthermore, dioscin, at a concentration of 10 micrograms/mL, had an inhibitory impact on the DNA synthesis of C6 glioma cells [63].
- Furthermore, the anti-cancer activity of methanolic fruit extract was investigated using the MTT (3-(4,5-dimethylthiazolyl)-2, 5-diphenyltetrazolium bromide) cytotoxicity assay in various cancer cell lines, including human nonsmall cell lung carcinoma (H1975), prostatecarcinoma (PC-3 and DU145), colorectal carcinoma (HCT116), and malignant melanoma (A375). It was shown that the fruit extract had the greatest cytotoxicity in prostatecarcinoma cell lines, with an IC50 of 8.48 µg/ml in DU145 cells and 11.18 µg/ml in PC-3 cells, respectively, in prostatecarcinoma cell lines. In contrast, extract was shown to be cytotoxic in H1975 cells, with an IC50 of 9.03 µg/ml in vitro. Extraction demonstrated cytotoxicity with an inhibitory concentration of 17.58 µg/ml in HCT116 cells and cytotoxicity with an inhibitory concentration of 27.94 µg/ml in A375 cells in a similar manner. In addition, fresh fruit of *S. indicum* has been demonstrated to cause considerable brine shrimp fatality, with lethal concentrations of 4.42 ± 0.67 (g/ml) (LC_{50}) determined for the fruit [64, 65].
- The fractionated test extracts of *Solanum indicum* Linn. from the in vitro work; identified as containing protodioscin, methylprotodioscin and methyl proto-prosapogenin A of dioscin, with solvent DMSO alone as a negative control and methotrexate as the positive control were studied. On determining the tumour weight post experiment, it was found that fractionated extract reduced tumour weight in a dose dependent manner upto forty-seven percent against methotrexate, which reduced tumour weight by sixty percent [63].

Haemolysis assay

The hemolysis activity of S. indicum, extracts was studied at various concentrations (0-128 g/ml) using human erythrocytes, and the results were promising. In the extract, there is no evidence of visible hemolysis activity [64].

Laxative action

The laxative properties of a crude methanolic extract of *S. indicum* fruits have been investigated in male wistar albino rats. The laxative action of the medicine was assessed by weighing the faeces matter after 8 and 16 hours of treatment with the drug. The laxative action of the extract was substantial, and it was shown to be dosage dependent. After 8 hours of treatment, it was discovered that the MeOH extract treated groups (250 and 500 mg/kg p.o.) had significantly larger feacal production (133.32 ± 1.136 mg and 149.01 ± 1.835 mg, respectively). After 8-16 hours, the test drug showed an increase in faecal output at both the conc. (258.8 ± 32.045mg) and the supplemental doses (293.66 ± 2.219mg) [66].

Cardiotonic activity

The cardiotonic action of methnolic extract of the fruits of *S. indicum* (5 and 10 mg/mL) was investigated using the heart of a frog (Bufo melanostictus). According to the findings, the extract produces significant cardiotonic action in a dosage dependent manner. The presence of MeOH extract at a concentration of 5 mg/ml results in a modest increase in the force of contraction but no significant change in the heart rate. Extract at a concentration of 10 mg/mL causes a considerable rise in the force of contraction and a small increase in the heart rate when tested. Despite the fact that the plant extract has a broad therapeutic index, it has not been shown to cause cardiac toxicity at higher levels evaluated up to 5 gm/mL [66].

CNS action

- Researchers employed an extract of the plant *Solanum indicum* dissolved in petroleum ether. The extract, according to the scientists, included alkaloids with psychotropic properties. It was studied if any changes in general behaviour of the test group occurred when albino mice were given an IP dosage of 40mg/kg body weight. In the study, the animals demonstrated drooping of their heads and were silent for one hour after being given an extract of Solanum indicum, which caused them to become sleepy. Aside from that, the animals exhibited no signs of becoming alarmed when exposed to external stimuli [67].

- Another study was carried out in order to investigate the effects of Abana, an Ayurvedic herbomineral preparation, on mice's memory and brain cholinesterase activity. *Solanum indicum* was used as the active ingredient in the formulation, which was designed to investigate the effects of Abana on memory and brain cholinesterase activity. The elevated plus maze and passive avoidance apparatus were used as the exteroceptive behavioural models for evaluating memory throughout the experiment. Diazepam and scopolamine were used as interoceptive behavioural models in this experiment. Abana (50, 100, and 200mg/kg, orally) improved the memory scores of both young and old mice in a dose-dependent manner, according to the results. Furthermore, it was shown to counteract the amnesia generated by scopolamine (0.4mg/kg, intraperitoneally) and diazepam (0.4mg/kg, intraperitoneally). Abana, when taken orally for 15 days, was shown to have a lowering effect on brain cholinesterase activity, which was unexpected. According to the authors, it may prove to be a beneficial treatment for Alzheimer's disease in the future [68].

Gastrointestinal action

- The anti-ulcerogenic properties of the methanolic extract of the fruit of *S. indicum* var. distichum have been examined in rats that have been subjected to aspirin and ethanol-induced ulceration. The extract (750 mg/kg) not only protects the stomach mucosa against the harmful effects of aspirin and ethanol, but it also has the additional benefit of promoting ulcer repair. Its antioxidant capacity, as shown by the restoration of antioxidant indicators such as glutathione, SOD, GR, CAT, and LPO, was most likely responsible for the result [69].

- A study was conducted on rats to determine the choleretic activity of a suspension of the fruit of *Solanum indicum*. Rats were initially anaesthetized with IP sodium pentabarbitone before being exposed to bile dust and cannulated with a catheter. It was necessary to collect the bile for one hour before administering the plant solution intraduodenally at a dosage of 500mg/kg. The therapy with *Solanum indicum* resulted in a 31 percent increase in bile flow. Conclusion: The difference in stimulation of bile flow in normal rats and the absence of hepatoprotective effects in normal rats showed that the two effects were mediated by separate active principles in herbal material, according to the authors' findings [70, 71].

CNS depressant activity

It was determined whether or whether adult wistar albino rats had increased spontaneous locomotor activity after being administered a methanolic extract of fruit. After 1 hour, the extract (500 mg/kg) displayed the greatest amount of locomotor inhibitory action. Medication's CNS depressant action was shown to be substantially superior to that of the conventional drug diazepam (0.5 mg/kg), according to the findings [67].

Antihypertensive activity

The effects of a standardised ethanolic extract of the *S. indicum* ssp. distichum fruit (containing > 0.15 percent chlorogenic acids) on blood pressure were studied in both normotensive and hypertension (N(W)-nitro-L-arginine methylester (L-NAME) treated rats. In normotensive rats, a four-week treatment with extract (30 mg/kg) had no impact on blood pressure. However, following L-NAME delivery, it stops the animal from developing hypertension [72].

CONCLUSION

In every part of the globe, plants are utilised for healing, survival, medicine, and sustenance by all members of the human race. Both in developing and developed countries, medicinal plants are still important in this regard. They have the potential to aid in the discovery of novel phytomedicines such as steroidal saponins, sesquiterpenoids, hydroxycoumarins, phenolic compounds, coumarins, coumarinolignoids alkaloids, saponin, fatty acids, glycerides of the oil, and triterpenes. It is becoming increasingly common to conduct translational research to investigate the therapeutic potential of plants associated with indigenous knowledge to benefit human health, as herbal therapy has fewer side effects and can play an important role in the advancement of sustainable health development. Translational research is being conducted to investigate the therapeutic potential of plants associated with indigenous knowledge to benefit human health. Many of the medicinal and biological properties of plants belonging to the genus Solanum are beneficial in a variety of applications, including antibacterial, antioxidant, anthelmintic, antiplasmodial, hepatoprotective, anticancer, laxative, cardiotonic activity, CNS depressant, and anti-hypertensive activity. It is believed that phytomolecules contained in these plants are responsible for a wide range of biological activities. There has been a slew of studies undertaken to investigate the traditional applications of Solanum species, and every one of them has found evidence to support the traditional claims. However, there are still a plethora of conventional applications that have not yet been assessed, which is a concern. To review the ethnobotanical applications, phytochemical profiles, and biological activities of the S. indicum, the authors utilised relevant types of literature to compile a comprehensive overview of the species. The bioactivities of *S. indicum* and their active phytoconstituents, which have been extracted from diverse plant sections of Solanum species, have also been demonstrated to have therapeutic potential, providing evidence for future medical uses of these species of the genus Solanum.

Acknowledgement

It is indeed our great pleasure to express our sincere gratitude and acknowledgement to the Chairman, Prof. (Dr) P. K. Singh, Lord Buddha Koshi Pharmacy, College, Saharsa, Bihar, India, for their encouragement and supports.

Conflict of interest statement

The author declares that there is no conflict of interest.

REFERENCES

1. Dey YN, Ota S, Srikanth N., Jamal M, WanjariM. A phytopharmacological review on an important medicinal plant-Amorphophallus paeoniifolius. AYU, 2012; 33(1):27-32. https://doi.org/10.4103/0974-8520.100303

2. Hussain MS, Ahamed KFH, Ravichandiran V, Ansari MZH. Evaluation of in vitro free radical scavenging potential of different fractions of Hygrophila auriculata (K.Schum) Heine. Asian Journal of Traditional. Medicine. 2009a; 5(2):51-59. https://doi.org/10.4314/ijhr.v2i1.55390

3. Hussain MS, Ahmed KFH, Ansari MZH. Studies on diuretic activity of Hygrophila auriculata (K. Schum) Heine in rats. International Journal of Hea.th Research. 2009b; 2(1):59-64. https://doi.org/10.4314/ijhr.v2i1.55390

4. Hussain MS, Azam F, Ahamed KFH. Ravichandiran V and Alkskas I. Anti-endotoxin effects of terpenoids fraction from Hygrophila auriculata (K.Schum) Heine in lipopolysaccharide-induced septic shock in rats. Pharmceutical Biology. 2016; 54(4): 628- 36. https://doi.org/10.3109/13880209.2015.1070877

5. Hussain MS, Fareed S, Ali M. Hygrophila auriculata (K.Schum) Heine: Ethnobotany, phytochemistry and pharmacology. Asian Journal of Traditional. Medicine 2010; 5(4):122 -31.

6. Hussain MS, Fareed S, Ali M. Preliminary phytochemical and pharmacognostical screening of the Ayurvedic drug Hygrophila auriculata (K.Schum) Heine. Pharmacognosy Journal. 2011; (3)23:28-40. https://doi.org/10.5530/pj.2011.23.5

7. Hussain MS, Fareed S, Ali M. Simultaneous HPTLC-UV530nm analysis and validation of bioactive lupeol and stigmasterol in Hygrophila auriculata (K.Schum) Heine (K. Schum) Heine. Asian Pacific Journal of Tropical Biomedicine. 2012b; S612-S617. https://doi.org/10.1016/S2221-1691(12)60283-4

8. Hussain MS, Fareed S, Ali M. Hyphenated Chromatographic Analysis of Bioactive Gallic acid and Quercetin in Hygrophila auriculata (K.Schum) Heine (K. Schum) Heine Growing Wildly in Marshy Places in India by Validated HPTLC Method. Asian Pacific Journal of Tropical Biomedicine. 2012c; S477-S483. https://doi.org/10.1016/S2221-1691(12)60257-3

9. Hussain MS, Fareed S, Ansari S, Rahman MA, Ahmad IZ, Saeed M. Current approaches toward production of secondary plant metabolites. Journal of Pharmacy and Bioallied Sciences. 2012a; 4(1):10-20. https://doi.org/10.4103/0975-7406.92725

10. Hussain MS, Eldarrat HA, Alkskas I, Mayoof JA, Dammona JM, Ismail H, Ali M, Arif M, Haque A. Anti-inflammatory, analgesic activity and molecular docking studies of Lanostanoic acid 3-O-α-D-glycopryranoside isolated from Helichrysum stoechus against chemically challenged experimental animal. Arabian Journal of Chemistry. 2020; 13(12):9196-9206. https://doi.org/10.1016/j.arabjc.2020.11.004

11. Kamboj VJ. Herbal medicine. Current Science. 2000; 78(1):35-39.

12. Pal SK and Shukla Y. Herbal Medicine: Present and Future. Asian Pacific Journal of Cancer Prevention. 2003; 4:281-288.

13. Ali M, Naquvi KJ, Sultana S. Nonpolar chemical constituents from the Oryza sativa L. bran. Journal of Scientific and Innovative Research. 2014; 3(6):583-587.

14. Ali M, Naquvi KJ, Sultana S. New phytoconstituents from Oryza sativa L. bran. Indian Drugs. 2016; 53(9):22-26. https://doi.org/10.53879/id.53.09.10277

15. Iyer KN and Kolammal M. Pharmacognosy of Ayurvedic Drugs. Dept. of Pharmacognosy. Govt. Ayurveda College, Trivandrum.1960; I (4)99.

16. Anonymous. The Ayurvedic Pharmacopoeia of India. Govt. of India. Ministry of health and Family welfare, Dept. of ISM&H (AYUSH), New Delhi. 2001. Part-1 Vol. III. pp. 27.

17. Anonymous. The Wealth of India, Raw Materials, Council of Scientific and Industrial Research, New Delhi, India. 1988. Vol. IX (Rh-So).

18. Sarin YK. Illustrated manual of Herbal drugs used in Ayurveda, Council of Industrial and Indian Council of Medical Research. 1996.

19. Vaidya BCV. Some controversial drugs in Indian medicine, Chaukhamba Orientalia, Varanasi. 1982.

20. Sukhdev. A selection of Prime Ayurvedic Plant Drugs Ancient-Mordern concordance, Anamaya Publishers, F-154/z. lado Sarai; New Delhi, India. 2006.

21. Kirtikar KR and Basu BD. Indian Medicinal Plants. Vol. I. Bishen Singh Mahendra Pal Singh, Dehra Dun India. 1991.

22. Sivarajan VV and Balachandran I. Ayurvedic drugs and their plant sources. Oxford and IBH, New Delhi. 1994.

23. Bhakta T. Common Vegetables of the Tribals of Tripura. Agartala, Tripura, India. Tripura Tribal Research Institute. 2004.

24. Bhattacharya AS, Chiranjivi Banaushadhi. 2nd volume, 3rd reprint. Kolkata: Ananda Publishers. 1982.

25. Jadavji TA. Caraka Samhita of Agnivesa, Elaborated by Caraka and Drinhbala with the Ayurveda Dipika commentry by Cakrapanidatta. Chaukhambha Vidyabhawan, Varanasi. 2011.

26. Sharma V, Hem K, Mishra A, Maurya SK. Time tested remedies for wound care from Ayurveda sciences. Innovative Journal of Ayruvedic Sciences. 2016; 1(1-3):1-3.

27. Jayanthy A, Maurya A, Verma SC, Srivastava A, Shankar MB, Sharma RK. A brief review on pharmacognosy, phytochemistry and therapeutic potential of Solanum indium L. used in Indian Systems of Medicine. Asian Journal of Research Chemistry. 2016; 9(3):127-132. https://doi.org/10.5958/0974-4150.2016.00022.5

28. Murthy GRS, Inamdar A and Rao VS. Organographic study of vessels in some solanaceae. Phytomorphology. 1980; 149-158. https://doi.org/10.1016/S0367-2530(17)31198-2

29. Anjana V, Kumari NO and Mathew PM. Trichomes in some south Indian species of Solanum L. Indian Journal Botanical Research. 2005. 1(1):65-72.

30. Anjana VN, Kumari NO and Mathew PM. Intra-specific variations of trichomes in the genus Solanum L. Biodiversity-conservation. 2008; 109-114.

31. Warrier PK, Nambiar VPK and Ramankutty C. Indian medicinal Medicinal plants. A compendium of 500 species. Orient Longman. Ltd. 1996: Vol.5.

32. Sharma V, Hem K, Seth A, Maurya SK. Solanum indicum Linn.: An ethnopharmacological, phytochemical and pharmacological review. Current Research Journal Pharmaceutical and Allied Sciences. 2017; 1 (2):1-9.

33. Revathi P and Parimelazhagan T Traditional Knowledge on medicinal plants used by the Irula Tribe of Hasanur Hills, Erode District, Tamil Nadu, India. Ethno botanical Leaflets. 2010; 14:136-60.

34. Sultana R, Khanam S, Devi K. Immunomodulatory effect of Solanum xanthocarpum fruits. International Journal Pharmaceutical Sciences Research. 2011; 2(2):93-7.

35. Rahmatullah M, Das AK, Mollik MAH, Jahan R, Khan M, Rahman T, et al. An Ethnomedicinal Survey of Dhamrai Sub-district in Dhaka District, Bangladesh. American Eurasian Journal of Sustainable Agriculture. 2009a; 3(4):881-8.

36. Rahmatullah M, Mollik MAH, Azam ATMA, Islam MR, Mahmood MA, Chowdhury MH, et al. Ethnobotanical survey of the Santal tribe residing in Thakurgaon District, Bangladesh. American Eurasian Journal of Sustainable Agriculture. 2009b; 3(4):889-98.

37. Gogoi B, Zaman K. Phytochemical constituents of some medicinal plant species used in recipe during 'Bohag Bihu' in Assam. Journal Pharmacognosy Phytochemistry. 2013; 2(2):30-40.

38. Kumar MR, Sathyabama S, Ramathilagam RD, Priyadarisini VB. Anti-Quorum sensing activity of medicinal plants and detection of N-

acyl-homoserine lactone signal molecules. International Journal of Integrative Biology. 2011; 11(1):21-5.

39. Kumar S, Plbag S, Maurya SK, Kumar D. Skin care in Ayurveda: A literary review. Int Res J Pharm. 2013; 4(3):1-3. https://doi.org/10.7897/2230-8407.04301

40. Gupta RB, Ahuja A, Sharma N, Kabra MP. Indigenous herbal plants used by tribes of Rajasthan; improving sexual performance and problem of sexuality. International Journal of Drug Development Research. 2013; 5(2):40-6.

41. Sathishpandiyan S, Prathap S, Vivek P, Chandran M, Bharathiraja B, Yuvaraj D, et al. Ethnobotanical study of medicinal plants used by local people in Ariyalur District, Tamilnadu, India. International Journal of Chemical Technology Research. 2014; 6(9):4276-84.

42. Namsa ND, Mandal M, Tangjang S. Mandal SC. Ethnobotany of the Monpa ethnic group at Arunachal Pradesh, India. Journal of Ethnobotany Ethnomedicine. 2011; 7(31):1-14. https://doi.org/10.1186/1746-4269-7-31

43. El-Aasr M, Miyashita H, Ikeda T, Lee JH, Yoshimitsu H, Nohara T, et al. A new spirostanol glycoside from fruits of Solanum indicum L. Chemical Pharmceutical Bulletin. 2009; 57:747-8. https://doi.org/10.1248/cpb.57.747

44. Yin HL, Li JH, Li B, Chen L, Li J, Tian Y, et al. Two new coumarins from the seeds of Solanum indicum. Journal of Asian Natural Product Research. 2014; 16(2): 153-7. https://doi.org/10.1080/10286020.2013.841142

45. Huang WH, Hsu CW, Fang JT. Central diabetes insipidus following digestion Solanum indicum L. concentrated solution. Clinical Toxicology (Phila). 2008; 46(4):293-6. https://doi.org/10.1080/15563650701385881

46. Deb PK, Ghosh R, Chakraverty R, Debnath R, Lakshman Das L and Bhakta T. Phytochemical and Pharmacological Evaluation of Fruits of Sola numindi cum Linn. International Journal of Pharmaceutical Sciences Review Research. 2014: 25(2).

47. Krishnaveni A, Selvi BK, Maheswari RU, Jayanthi B and Maheswari DU. Antibacterial activity of fruit extracts of Solanum indicum. Indian Journal of Natural Products. 2005; 21(4):58-59.

48. Gavimath CC, Kulkarni SM, Raorane CJ, Kalsekar DP, Gavade BG, Ravishankar BE and Hooli RS. Antibacterial potentials of Solanum indicum, Solanum xanthocarpum and Physalis minima. International Journal of Pharmaceutical Application. 2012; 3(4):414-418.

49. Jayanthy A, Sulaiman CT and Rema Shree AB. Pharmacognostical and Phytochemical Comparison of Roots of Solanum species used in Ayurvedic Formulations. Proceedings of Second National Seminar on Genetics, Breeding and Biotechnology. Interuniversity Centre for Plant Biotechnology, Dept. of Botany, University of Calicut. 2011; 22.

50. Srividya AR, Arunkumar A, Cherian B, Maheshwari V, Piramanayagam S, Senthoorpandi V. Pharmacognostic, phytochemical and antimicrobial studies of Solanum indicum leaves. Anc Science Life. 2009; 29(1):3-5.

51. Kouadio AI, Chatigre OK, Dosso MB. Phytochemical screening of the antimicrobial fraction of Solanum indicum L. berries extract and evaluation of its effect against the survival of bacteria pathogens of plants. International J of Biotechnology Food Sciences. 2014; 2(1):21-30.

52. Kouadio AI, Oulahal N, Thi PN, Adt I, Degraeve P. Study of the antimicrobial activities of Solanum indicum ssp. Distichum (Schumach. and Thonning 1827) fruits ("gnangnan" berries) from a tropical humid zone (Côte d'Ivoire). International Journal Biology Chemical Sciences. 2011; 5(3):1190-200. https://doi.org/10.4314/ijbcs.v5i3.72254

53. Deb PK, Das N, Bhakta RGT. Evaluation of in-vitro Antioxidant and Anthelmintic Activity of Solanum indicum Linn. Berries. Indo American Journal of Pharmaceutical Research. 2013a; 3(2):4123-30.

54. Hasan RU, Prabhat P, Shafaat K, Khan R. Phytochemical investigation and evaluation of antioxidant activity of fruit of Solanum indicum Linn. International Journal of Pharmacy and Pharmceutical Sciences. 2013; 5(3):237-42.

55. N'dri D, Calani L, Mazzeo T, Scazzina F, Rinaldi M, Rio DD, Pellegrini N, et al. Effects of different maturity stages on antioxidant content of Ivorian Gnagnan (Solanum indicum L.) berries. Molecules. 2010; 15(10):7125-38. https://doi.org/10.3390/molecules15107125

56. Bhuvaneswari B, Suguna MML. Hepatoprotective and antioxidant activities of Solanum indicum Linn. Berries. International Journal of Clinical Toxicology. 2014; 2:71-6. https://doi.org/10.14205/2310-4007.2014.02.02.4

57. Narayanaswamy N, Balakrishnan KP. Evaluation of some Medicinal Plants for their Antioxidant Properties. International Journal of Pharmaceutical Technology and Research. 2011; 3(1):381-5.

58. Senaratne UVR, Perera HKI, Manamperiand A, Athauda SBP. Partial purification of anthelmintic compounds from Solanum indicum. Proceedings of the Peradeniya University Research Sessions, Sri Lanka. 2011; 16.

59. Anwikar S, Bhitre M. Study of the synergistic anti-inflammatory activity of Solanum xanthocarpum Schrad and Wendl and Cassia fistula Linn. International Journal of Ayurveda Research. 2010; 1(3):167-71. https://doi.org/10.4103/0974-7788.72489

60. Zirihi GN, Mambu L, Guédé-Guina F, Bodo B, Grellier P. In-vitro antiplasmodial activity and cytotoxicity of 33 West African plants used for treatment of malaria. Journal of Ethnopharmacology. 2005; 98(3):281-5. https://doi.org/10.1016/j.jep.2005.01.004

61. Ghassam BJ, Ghaffari H, Prakash HS, Kini KR. Antioxidant and hepatoprotective effects of Solanum xanthocarpum leaf extracts against CCl4-induced liver injury in rats. Pharmceutical Biology. 2014; 52(8):1060-8. https://doi.org/10.3109/13880209.2013.877490

62. Syu W, Don M, Lee G, Sun C. Cytotoxic and novel compounds from Solanum indicum. Journal of Natural Products. 2001; 64(9): 1232-3. https://doi.org/10.1021/np010186v

63. Chiang HC, Tseng TH, Wang CJ, Chen CF, Kan WS. Experimental antitumor agents from Solanum indicum L. Anticancer Research. 1991; 11(5):1911-7.

64. Gopalakrishna SM, Thimappa GS, Thylur RP, Shivanna Y, Sreenivasan A. In-vitro anti-cancer screening of Solanum indicum Rhus succedanea, Rheum emodi and Gardenia gummifera medicinal plants in cancer cells. Research Review Journal of Pharmaceutical Sciences. 2014; 3(4):22-30.

65. Rahman MS, Begum B, Chowdhury R, Rahman MK, Rashid MA. Preliminary Cytotoxicity Screening of Some Medicinal Plants of Bangladesh. Dhaka University Journal of Pharmceutical Sciences. 2008; 7(1):47-52. https://doi.org/10.3329/dujps.v7i1.1217

66. Deb PK, Das L, Ghosh R, Debnath R, Bhakta T. Evaluation of laxative and cardiotonic activity of Solanum indicum Linn fruits. Journal of Pharmacy and Phytotherapy. 2013b; 1: 3:11-4.

67. Deb PK, Ghosh R, Chakraverty R, Debnath R, Lakshman Das L and Tejendra Bhakta T. Phytochemical and Pharmacological Evaluation of Fruits of Sola numindi cum Linn. International Journal of Pharmceutical Sciences Review Research. 2014: 25(2):11-4.

68. Parle M, Singh N. Reversal of memory deficits by atorvastatin and simvastatin in rats. Yakugaku Zaashi, 2007; 127: 1125-1137. https://doi.org/10.1248/yakushi.127.1125

69. Abeer YI, Nermeen M S. Protective Effect of Solanum indicum Var. Distichum extract on experimentally induced gastric ulcers in rat. Global Journal of Pharmacology. 2013; 7 (3):325-32.

70. Al-Oqail HM, Hassan WHB, Ahmad MS, Al-Rehaily AJ. Phytochemical and biological studies of Solanum schimperianum. Saudi Pharmceutical Journal. 2012; 20:371-9. https://doi.org/10.1016/j.jsps.2012.05.010

71. Asha VV, Pushpangadan P. Preliminary evaluation of the antihepatotoxic activity of Phyllanthus kozhikodianus, P. maderaspatens is and Solanum indicum. Fitoterapia. 1998; 69(3):255-259.

72. Bahgat A, Abdel-Aziz H, Raafat M, Mahdy A, El-Khatib AS, Ismail A, et al. Solanum indicum ssp. distichum extract is effective against LNAME- induced hypertension in rats. Fundamental & Clinical

Pharmacology. 2008; 22(6):693-9. https://doi.org/10.1111/j.1472-8206.2008.00627.x

73. Yahara S, Nakamura T, Someya Y, Matsumoto T, Yamashita T, Nohara T. Steroidal glycosides indiosides A-E, from Solanum indicum. Phytochemistry. 1996; 43(6):1319-23. https://doi.org/10.1016/S0031-9422(96)00395-0

74. Kirtikar KR, Basu BD, Indian Medicinal Plants, 2nd ed. Vol. II. International Book Publication Distribution, Dehradun, India, 1995; 1755-7.

75. Chopra RN, Nayer SL, Chopra IC. Glossary of Indian Medicinal Plants. New Delhi: PID, CSIR. 1992.

76. Khare CP. Indian Medicinal Plants-An Illustrated Dictionary. First Indian Reprint, Springer (India) Pvt. Ltd. New Delhi. 2007. https://doi.org/10.1007/978-0-387-70638-2

77. Puntambekar SV, Krishna S. Fatty oil from the seeds of Solanum indicum Linn. Journal Indian Chemical Society. 1941; 18:329-34.

78. Yin HL, Li JH, Li J, Li B, Chen L, Tian Y, et al. Four new coumarinolignoids from seeds of Solanum indicum. Fitoterapia. 2013; 84360-5. https://doi.org/10.1016/j.fitote.2012.09.002

79. Bhattacharya AS, Chiranjivi Banaushadhi. 2nd volume, 3rd reprint. Kolkata: Ananda Publishers. 1982.

80. Jaiswal V, Singh SK, Singh AK, Maurya SK. A critical review on antiasthmatic Ayurvedic medicinal plants and compound Formulations. International Journal of Pharmacy Archive. 2014; 3(5):400-9.

81. Gu G, Du Y, Linhardt RJ. Facile synthesis of saponins containing 2,3-branched oligosaccharides by using partially protected glycosyl donors. Journal of Organic Chemistry. 2004; 69(16): 5497-500. https://doi.org/10.1021/jo0493929

82. Gopalakrishna SM, Thimappa GS, Thylur RP, Shivanna Y, Sreenivasan A. In- vitro Anti-Cancer Screening of Solanum indicum Rhus succedanea, Rheum emodi and Gardenia gummifera Medicinal Plants in Cancer Cells. Research Review Journal of Pharmaceutical Sciences. 2014; 3(4):22-30.

83. Mishra A, Seth A, Maurya SK. Therapeutic significance and pharmacological activities of Antidiarrhoeal medicinal plants mention in Ayurveda: A review. Journal of Intercultural Ethnopharmacology. 2016; 5(3):290-307. https://doi.org/10.5455/jice.20160426094553

84. Mishra A, Sharma V, Hem K, Maurya SK. Plants used for treatment of diarrhea: an Ayurvedic prospective. Innovative Journal of Ayruvedic Sciences. 2015; 3(1):1-6.

85. Malhotra SR, Kumar D. Euphorbia hirta: Its chemistry, traditional and medicinal uses, and pharmacological activities. Pharmacognosy Review. 2010; 4(7):58-61. https://doi.org/10.4103/0973-7847.65327

86. Maurya SK, Seth A, Gautam DNS, Singh AK. Biodiversity and indigenous uses of medicinal plant in the Chandra Prabha Wildlife Sanctuary, Chandauli District, Uttar Pradesh. International Journal of Biodiversity. 2015; 2015:394307. https://doi.org/10.1155/2015/394307

87. Maurya SK, Seth A. Potential medicinal plants and traditional Ayurvedic approach towards urticaria, An allergic skin disorder. International Journal of Pharmceutical Sci. 2014; 6(5):172-7.