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Review Article

A systematic review on Solanum xanthocarpum L. (Solanaceae) plant and its potential pharmacological activities

Sandip G. Laware* and Nitin L. Shirole

Department of Pharmacy, DCS's Annasaheb Ramesh Ajmera College of Pharmacy Nagaon, Dhule, Maharashtra, India

E- mail: sglaware2015@gmail.com

Abstract

Solanum xanthocarpum plant is also known as the Yellow Berried Nightshade or Kantkari in Sanskrit belonging to the family Solanaceae. In Ayurveda, this plant has described the herb as a bitter, digestive, pungent, and alternative astringent in ancient times. This plant is most widely found in the Indian regions in tropical and warm temperature regions. This is the prickly herb and most important in the traditional system and one of the members of Dasamula of the Ayurveda. This herb belongs to panchmulas which includes solasodine and diosgenin. Due to the presence of the prickles in the herb, it is also known as the Duhsparsa, its meaning is difficult to touch. The plant has a variety of pharmacological activities like Larvicidal activity, Bacterial activity, Antihyperglycemic, Antioxidant, Hepatoprotective activities. Many researchers have been investigated the therapeutic activity of the plant which has been described in the review. Solasodine and diosgenin are the main chemical constituents present in the plant and have therapeutic activity. The whole plant possesses various potential uses including eco-friendly attributes. The present review is the summarization of all available data of *Solanum xanthocarpum* and the compilation of all updated information of its pharmacological activities and phytochemical constituents.

Keywords: *Solanum xanthocarpum*, Antioxidant, Hepatoprotective, Larvicidal, Bactericidal

INTRODUCTION

Herbal medications are utilised by almost 80% of the world's population for basic health care, particularly in developing nations. In the next years, evaluating the existing state of the healthcare system in terms of synthetic drug adequacy will become increasingly evident. It has been stated that the number of diseases and disorders caused by synthetic medications has increased alarmingly, forcing a shift to traditional herbal medicine (Parmar et al., 2010; Goldberg, 1994; Rita & Animesh, 2011).

Over 1, 08,276 bacteria, fungi, animals, and plants have been identified and characterized in India. Ayurveda is an ancient Indian medical system that has been practiced for thousands of years. Ayurvedic medicinal herbs have been the subject of much research in pharmacognosy, chemistry, pharmacology, and clinical treatments. Allopathy and the current medicinal system is gradually developed nowadays by scientific and observational efforts of the scientist. However, traditional medicine and therapies remain at the heart of their development (Parmar et al., 2010).

For the development of the new drugs from plants, selection of the biological plant and its evaluation depending on the traditional use of the plants is the best approach. The present review is based on such a plant that is *Solanum xanthocarpum* (SX) Schrad. & Wendl. (Family: Solanaceae) which is also known as Indian nightshade or Yellow berried nightshade in English and Kantakari in Sanskrit (Parmar et al., 2010). This plant is one of the members of Dasamula means ten roots from Ayurveda. It is the science of life,

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prevention, and longevity, and the most holistic medical system, This herb belongs to panchmulas which includes solasodine and diosgenin. Due to the presence of the prickles in the herb, it is also known as the Duhsparsa, its meaning is difficult to touch. In Ayurveda, three species have been mentioned which include violet flowered, yellow-flowered, and white-flowered (Rita & Animesh, 2011). The review consists of all studies of the plant *Solanum xanthocarpum* including taxonomical classification, cultivation, phytochemical constituents, medicinal properties along with its pharmacological activities.

The plant is 2-3 m in height and is especially found in India in a dry place. In ancient times. Ayurveda describes the herb as a bitter, digestive, pungent, and alternative astringent in ancient times. Bitter and carminative stems, flowers, and fruits. Leaf of the Solanum xanthocarpum shows varieties of pharmacological activities which include, antifungal, wound healing, antibacterial, antihyperglycemic, antioxidant, hepatoprotective, and larvicidal. Steroidal alkaloids are the main chemical constituents mainly found in the fruits of this plant. Fruits of this plant show many pharmacological activities like antipyretic, anthelmintic, anti-inflammatory, urinary bladder, enlargement of the liver, laxative, anti-asthmatic activities. The root part of the plant is also very effective which acts as a diuretic and is used in febrifuge, and expectorant, cough, asthma, and chest pain. Several formulations contain it, including Chavanaprasha, Dasamoolarishta, Vyaghriharitaki avaleha, Vyaghri tailam, Vyaghriyadi kwatha, Vyaghri ghrtam, and others (Fathima et al., 2019; Singh & Singh, 2010; Paul et al., 2008; Bhutani et al., 2010; Vadnere, 2008)

Synonyms: Kantakari, Vyaghri, Dhavani, Kshudra, Kantakarika, Kantalika (Pharmacopoeias, 1999)

Regional Names: English -Febrifuge Plant, Hindi-Katali, Bhatakataiya, Chhotikateri, Ringani, Telugu-Nelamulaka, Chinnamulaka, Mulaka, Pinnamulaka, Kannada-Kiragulla, Nelagulla, Tamil-Kandangatri, Kandan Katri, Kandanghathiri, Gujarati: Bhoringan (Pharmacopoeias, 1999).

Description and distribution

It is a green perennial herb having a woody base and stem that is zigzag. It is a very prickly diffuse bright green herb. Its branches are numerous and prickles are compressed and yellow, glabrous and shining which are 1.3 cm in length. Length of leave is 2.5-5.7 cm and oval in shape or maybe elliptic, stellately hairy on both sides. Armed on midrib with long yellow sharp prickles, its base is unequal and rounded, the petiole is 1.3 to 2.5 cm and hairy. Berries of this plant are green and having white stripes at the young stage, and yellow on aging. These are 1.3 to 2cm in diameter (**Figure 1**). It is connected with enlarged calyx which is 1.3 cm long, hairy, and prickly. Seeds are 2.5 mm in diameter and glabrous, Outside, the lobes are 11 mm long, linear-lanceolate, sharp, and hairy. Anthers are 8 mm long, oblong-lanceolate, and open by small pores. Filaments are 1.5 mm long and glabrous. Ovary is ovoid, glabrous; style glabrous.

This plant is widely found in India, in Uttar Pradesh, West Bengal, Assam, Bihar, Punjab, etc. And also found in Ceylon and Malacca through South-East Asia, tropical Australia, and Polynesia. Its cultivation period is March to April and fruiting period is from May to June. It is mostly found in hot and dry places (Pol eta l., 2016; Watt, 1893; Ara, 1988).

Taxonomical classification of the plant

Botanical name: *Solanum xanthocarpum*, a kingdom: Plantae, division|: Magnoliophyta, Class: Magnoliopsida, subclass: Asteridae, order: Solanales, Family: Solanaceae, Genus: Solanum (Fathima et al., 2019).

Figure 1: *Solanum xanthocarpum*: Leaves, fruit, flower, seeds.

Cultivation

For the cultivation of this plant, rich loamy soil is required which is well-drained and having a pH range between 7 to 8. This plant grows in saline soil as well. The temperature required for this cultivation is 21 to 27°C. This crop was adversely affected by the frost and it recovered during spring. The seeds are raised from the crop and their diameter is about 2.5mm. These seeds have no latency period. Its germination range is between 60 to70% and the germination period is around 10 to 16days (Fathima et al., 2019).

Phytochemical constituents

Saiyed and Kanga studied the chemical examination of the berries of the plant which included the separation of glycoalkaloid and solanine. In the non-alkaloid part, β-sitosterol glycoside and galactose sugar moiety was obtained along with the two phenolic substances and it was identified as methyl caffeate and caffeic acid (Saiyed & Kanga, 1936; Gupta & Dutt, 1938).

Fruits consist of steroidal alkaloids like solanacarpine solamargine and also consist of other chemical constituents like caffeic acid, coumarins like aesculetin and aesculin, carpesterol, diosgenin, campesterol, daucosterol, and triterpenes like cycloartanol and cycloartenol were reported (Tupkari et al., 1972; Sato & Latham, 1953; Friedman et al., 1997). Steroidal glycoalkaloids are secondary plant metabolites that occur naturally in a variety of foods, including potatoes, tomatoes, and eggplants. Glycoalkaloids and hydrolysis products without the carbohydrate side chain (aglycons) have positive effects, even though they are potentially poisonous. These are having the activity in the reduction of cholesterol, it protects in infection of Salmonella species, and also used in the treatment of cancer, used as general anesthetics which acts by inhibiting the cholinesterase, use as malaria vaccine. Solanidine exhibits estrogenic activity in in vitro assay (Tupkari et al., 1972). Structures of some phytoconstituents are given below (**Figures 2-7**).

Fruit contains alkaloid saponins, which are extracted using alcohol and have a heart-stimulating effect. The fruits had a dry seed content of 20.71%, a pericarp content of 4.62%, and a moisture content of 74.67%. The powdered seeds were extracted with benzene, yielding 19% greenish-yellow oil that was nitrogen and sulphur free. The oil's composition was calculated to be 42.93% oleic acid, 36.18% linolic acid, 5.37% palmitic acid, 9.77% stearic acid, 0.35% arachidic acid, and 1.2% unsaponifiable materials (Gupta & Dutt, 1938; Tupkari et al., 1972) Berries are the main sources of the Solasodine, this is the spiroketal alkaloid sapogenin having heterocyclic nitrogen atoms. It is the initial material for the production of cortisone and sex hormones. Solasodine is

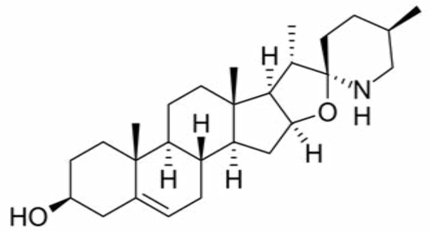
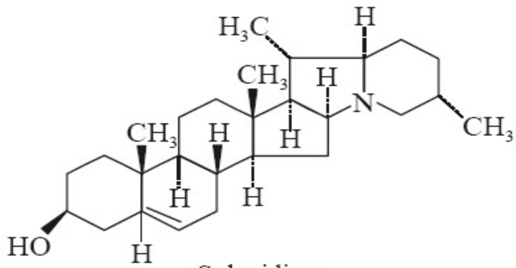


Figure 2: Shows the structure of Solasodine.



Solanidine

Figure 3: Shows the structure of Solanidine.

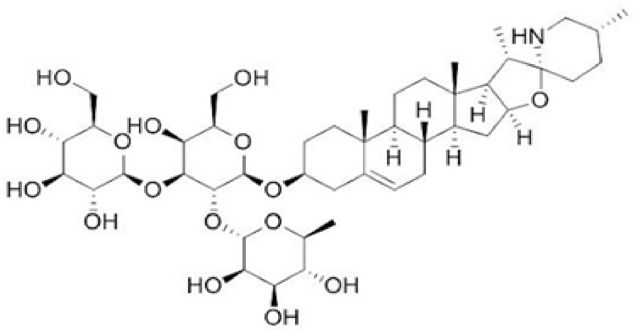


Figure 4: Shows the structure of Solasonine.

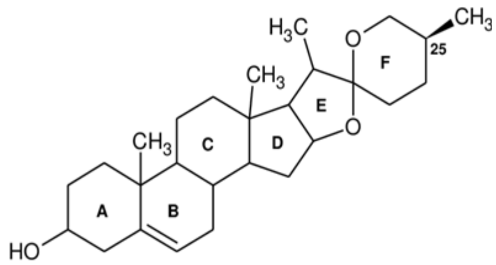


Figure 5: Shows the structure of Diosgenin.

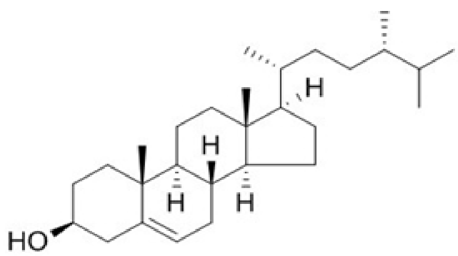


Figure 6: Shows the structure of Campesterol.

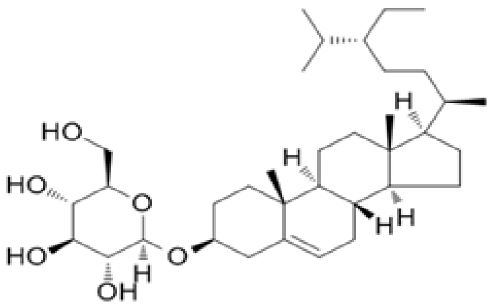


Figure 7: Shows the structure of Daucosterol.

an N-analogue of diosgenin that is utilized as a steroidal precursor in the steroid industry to make corticosteroids, antifertility medicines, and anabolic steroids, among other things and this available in the form of glycoside in various berries in the plants having genus Solanum and glycosides which are available in berries are known to be solasonine, solamargine. These chemical moieties have the common spiro aminoketal alkaloid or called aglycon namely Solasodine. About 1.1% to 4.6% of Solasodine is found in the berries of the plant. These berries are collected in the autumn season depending upon the climatic and soil condition which will result in more content of solasonine and solamargine and solasurine can be obtained in summer. In unripe berries, the content of Solasodine is only 1.7% (Weissenberg et al., 1998).

Estimation of the Solasodine can be done by various methods like chromatography method, Potentiometry method, colorimetric method or by RIA. There are different kinds of analytical methods like high-performance liquid chromatography, High-performance thin layer chromatography, capillary electrophoresis, gas chromatography, etc, that are available for the determination of solasodine from the plant (Kadkade & Rolz, 1977; Laurila et al., 1999). Emmanuel et al., (2006) found that the plant has a sufficient level of solasodine (0.84%). They also found that altering the temperature, extraction duration, and hydrochloric acid concentration affected the % age recovery of solasodine. In no instance should the temperature of extraction, hydrolysis, basification, or purification be high during the estimation procedure, since this may alter the actual recovery of Solasodine. At 196-197°C melting point pure white solasodine crystals may be formed. Solasodine is a nitrogenous diosgenin analogue that can be converted to progesterone, a steroidal sex hormone used in oral contraception. Solasodine showed an anti-inflammatory effect against carrageenan-induced paw edema in rats, according to S. Emmanuel's (2006) research. From 19.5 to 56.4%, the extract and its component solasodine significantly reduced the inflammatory response.

Heble et al. studied the isolation and identification of ß-sitosterol and diosgenin which is obtained from callus tissues of the plant. Diosgenin was isolated from the chemical examination of the berries. The minute amount of the steroidal alkaloid solasonine and solanine was detected. The tissue culture showed the ß-sitosterol and diosgenin in more quantities than obtained in the growing plant (Heble et al., 1968). Carpesterol and a steroidal alkaloid glycoside were isolated by Saiyed and Kanga (1936). Carpesterol was the first substance isolated from a plant's lipid fraction, but no structural investigations of the sterol were published until more than three decades ago. Because it was thought that understanding the structure of carpesterol would provide insight into the biogenetic pathway leading to solasodine, the main alkaloid found alongside carpesterol in SX and in many other Solanum species. Subsequent analyses of extracts from SX confirmed the presence of diosgenin and β-sitosterol.

Chungath & Nair, (1989) found that the solasodine content varied at different stages of fruit maturation, such as when the berries were green in hue, and when the colour changed from green to yellow. The berries of SX in the early phases of fruit growth are quite small, green in colour, and have white blotched stripes, according to the findings. On ripening of fruit, it gives a yellow colour. Berries turn a rich golden colour as they sit longer in the plant, at which point the stalk through which the berries are attached turns brown instead of green. There is variation in the steroidal glycoalkaloid when the fruit is get matured, therefore the steroidal alkaloid content was observed. For the determination of Solasodine content colorimetric method was used. Solasodine is the complex yellow coloured compound methyl orange extractable in chloroform. cycloartanol, cycloartenol, sitosterol, stigmasterol, campesterol, cholesterol, sitosterol glucoside are the chemical constituents extracted from the fruits of the Solanum xanthocarpum.

Traditional use of the plant

This herb is used in various treatments of diseases like asthma includes bronchial asthma, cough, chest pain, to stop vomiting, hair fall, leprosy, itching, scabies and various skin diseases. This herb is also used in cardiac diseases as well as in wound healing. Solanum xanthocarpum is also used in the treatment of diabetes. Solasodine is the main chemical constituent of the plant which has many therapeutic activities which include, including anti hyperglycemic activity, antipyretic, anthelmintic, carminative, stomachic, laxative, febrifuge, and aphrodisiac properties apart from promoting conception. Roots of the plats are used in Dashmularishtha which is the Ayurvedic tonic for lactating mothers and it is mostly used in the rural areas. Root paste is used by the Mukundara tribals of Rajsthan in the treatment=t of Hernia. Roots of the plant are also to relieve flatulence and heal constipation. Fruits and flowers are also used in the burning sensation of the foot. These leaves can apply to the body to relieve body pain its juice along with black pepper is used in rheumatism. Berries juice is used in curing the sore throat and also in dental pain, its dry powder in the form of cigars is used. Fruit extracts have anti-inflammatory activity. Linctuses made from flower stamens are used to treat persistent cough in youngsters (Bangasena). Kantkari Ghrita of Charaka is specific for cough and asthma. Traditional medicine has employed the entire plant to treat a variety of diseases. Decoction of the plant is used in gonorrhea; The plant is also known to have pest repellent properties and is used as a contact poison and molluscicide. Roots are a component of the well-known Ayurvedic concoction "Dasmul Asava," which is used as an expectorant, cough reliever, asthma reliever, and chest pain reliever in Ayurvedic medicine (Parmar et al., 2010; Goldberg, 1994; Rita & Animesh, 2011; Fathima et al., 2019; Singh & Singh, 2010; Paul et al., 2008; Bhutani et al., 2010).

Pharmacological activity

The plant has many pharmacological activities which include antifertility activity, anti-inflammation activity, hepatoprotective activity, cardiovascular effects, apoptosis-inducing activity, anti-asthmatic activity, anti-oxidant activity, hypoglycemic, mosquito larvicidal, locomotor activities snail killing and anti-allergic activity.

Anti-fertility activity

Solasodine is a chemical compound that is an alkaloid and extracted from the plant. It has anti spermatogenic activity. It inhibits testosterone but has no effects on estrogen. Due to the administration of solasodine, acid phosphatase enzyme activity gets reduced. Testicular lesions are caused due to the continuous use of solasodine which is responsible for the severe spermatogenic elements impairment (Dixit & Gupta, 1982; Dixit, 1980; Gupta et al., 2011).

Hepatoprotective activity

This investigation was done by Chandana VR et al. Evaluation was done on rats, toxicity was induced by CCl4. This CCl4 is converted into the CCL3 which is the main reason for hepatotoxicity. There was an increase in the concentration of the enzyme and which was treated by the *Solanum xanthocorpum*. Jigrine is an herbal formulation that is used in the treatment of liver disorders. It contains the active constituent of Solanum xanthocorpum. Nazmi AK, et al also found the scavenging activity of DPPH free radicals. It is an antioxidant activity (Najmi et al., 2005; Kenny et al., 2013).

Anti-inflammatory activity

Carpesterol, diosgenin, and stigmasterol are the chemical constituents from solanum xanthocorpum having anti-inflammatory activity. Inflammation is an unusual reaction that occurs in chronic diseases like autoimmune disease, cancer and vascular disorders and arthritis. solanidine, alpha solanine, and alpha chaconine have anti-inflammatory actions. These are potential constituents from the *Solanum xanthocorpum* for the treatment of inflammation. Lupeol is also having action against inflammation. The key molecular pathways involved in this activity are, phosphatidylinositol-3kinase, Kappa B, cFLIP and Kras nuclear factors in different cells. Lupeol is used as a chemo preventive agent as well as used in the treatment of inflammation (Gabay et al., 2010; Chaturvedi et al., 2008).

Cardiovascular activity

Pasnani JS investigated the cardiovascular activity of solasodine for the formulation Ababa which is the polyherbal formulation. the activity includes direct sensitization of the atrium through an increase in permeability of Ca^{+} ions and disengagement of chronic ISO administration which is the downregulation of beta-adrenoreceptors (v et al., 2008).

Apoptosis-inducing activity

Solamargine and apigenin are the chemical constituents from *Solanum xanthocarpum* which has anticancer activity. It was observed in the solamargine-treated cells of the sub-G1, DNA fragmentation and condensation of chromatin in DNA suggested that apoptosis was induced by solamargine. Bhutani KK studied that, The plant consists of steroidal alkaloids which cause the death of the tumor cells and these components are responsible for giving the potential therapeutic activity against cancer (Gupta et al., 2005; Ondrusek et al., 1981; Alarcon et al., 2006).

Anti-asthmatic activity

Gautam et al have studied and evaluated the whole use of the plant which also includes asthma relieving action as well as anti-allergic properties. Pilot studies are undertaken for proving the potent effect of Solanum xanthocarpum in the treatment of asthma. It was demonstrated that the ethanolic extract has antihistaminic activity in histamine-induced constriction in the goat tracheal chain. Also its ethanolic concentrate bloom on the disconnected goat trachea (Alarcon et al., 2006; Chiang et al., 2007).

Hypoglycemic activity

At 100 and 200 mg/kg, the aqueous concentrate had a significant hypoglycemic effect in both normal and streptozotocin-induced diabetic animals. This action is similar to glibenclamide. It showed a strong reduction of blood glucose levels in ordinary and streptozotocin actuated diabetic rodents (Batabyal et al., 2007).

Locomotor activity:

Effects of scopolamine were observed in the rats which are related to the action of dopaminergic function. The behavioral effects of spiperone on apomorphine can be reduced by administering scopolamine. In mice exposed to 6-hydroxydopamine, methyl tyrosine suppresses the enhanced scopolamine locomotor activity. When rats are given 6-OHDA together with -methyltyrosine, the inhibitory activity of spiperone is inhibited. In the brain, unchanged levels of dopamine-related activities of adenylate cyclase and 3Hspiperone confirm scopolamine's postsynaptic connection (Moha et al., 2005; Mamta et al., 2016).

Suppressing effect

Cancer that overexpresses HER2 The diosgenin isolated from *S. xanthocarpum* suppresses the expression of FAS in breast cells. This is because the extract's diosgenin is responsible for inhibiting proliferation as well as triggering apoptosis in HER2- overexpressing cancer cells. The cytotoxicity of paclitaxel-induced HER2 overexpression can be increased by diosgenin. As a result, diosgenin has the potential to be used as a chemoprotective drug in the treatment of malignancies that overexpress HER2 (Govindan et al., 1999).

Antifilarial effect

Mohan et al. (2005) studied the potential of crude extract of *Solanum xanthocarpus* plant against larvae and it was suggested that it is an eco-friendly, effective larvicide in the management of mosquito population so that it can break the different vector-borne epidemics.

Mosquito larvicidal effect

The fruit extracts of the plant revealed larvicidal activity against An. stephensi and Cx. Quinquefasciatus and one culicine species Ae. Aegypti. Volatil oil obtained from the plant is effective against the species *Cx. Quinquefasciatus*. The fatal concentrations of fruit extract against *An. culicifacies, An. stephensi*, and *Aedes aegypti* at LC50 and LC90 levels were determined to be 0.112 and 0. 258, 0.058 and 0.289, and 0.052 and 0.218%, respectively. Although at higher concentrations than the fruit extract, the root extract is efficient against anopheline and culicine mosquito species (Batabyal et al., 2007).

Miscellaneous activities

The plant shows anti-androgenic activity due to the presence of Solasodine which is the alkaloid constituent and it is studied by Dixit VP. Solasodine was found to have antifertility effects in male rats and canines in a subsequent investigation. *Aspergillus niger* and *Trichoderma viride* radial growth was inhibited by carpesterol and four steroidal glycosides extracted from methanol extract of *Solanum xanthocarpum* fruits. *Solanum xanthocarpum* dried fruit tissues methanolic extract had antifungal efficacy against *A. brassicae*. In mice, a methanolic extract of *Solanum xanthocarpum* aerial portions reduced the frequency of acetic acid-induced belly constriction considerably and dose-dependently (Dixit, 1980).

LITERATURE REVIEW

Govindan et al., (2004) studied the clinical efficacy of *Solanum xanthocarpum* in the treatment of bronchial asthma. The clinical efficacy and safety of a single dose of the aforesaid herbs in mild to moderate bronchial asthma were investigated in a pilot study. For comparison, standard bronchodilator medications such as salbutamol (4 mg) and deriphylline (200 mg) were utilised. In asthmatic individuals, treatment with *S. xanthocarpum* or *S. trilobatum* dramatically improved different pulmonary function indices. The findings of this investigation back up the traditional belief that certain herbs can help with bronchial asthma. Hussain et al., (2012) assessed the hepatoprotective effect of Solanum xanthocarpum fruit extract against antitubercular drug-induced liver toxicity in experimental animals. In this study, the toxicity of the liver was induced by antitubercular drugs i. e. isoniazid, rifampicin, and pyrazinamide in rats. Different biochemical parameters were assessed where in vivo antioxidant activity was observed in rat liver homogenate. The biochemical observations were supplemented by histopathological examination. The findings of this study strongly suggest that *S. xanthocarpum* has a protective effect against liver injury, which could be ascribed to its hepatoprotective action, and so scientifically back up its traditional use.

Kumar et al., (2010) studied to see how its fruits affected experimentally produced excision and incision wound models in Sprague Dowlay rats. The methanolic fruit extract was prepared in white petroleum jelly at a concentration of 10% by weight. Compared to the control, the % wound healing was much higher in the excision wound model (51.2%, 36% and 30% at 4^{th}, 8^{th} and 12^{th} day of wound creation). The results suggested that methanolic fruit extract of *S. xanthocarpum* possesses significant wound healing potential.

Patel K et al., (2012) carried out a study to rationalize and investigate the usage of Solanum xanthocarpum in the treatment of kidney stones. By *in vitro* and *in vivo* studies, the saponin-rich fraction was prepared for evaluation of antiurolithiatic activity. Urolithiasis was induced and saponin-rich fraction was selected by dose fixation study. Biochemical parameters were measured in urine, serum and kidney homogenate. *Solanum xanthocarpum's* antiurolithiatic activity was thought to be mediated through the prevention of CaOx crystal formation.

Poongothai et al., (2011) studied the Antihyperglycemic and antioxidant effects of *Solanum xanthocarpum* leave extracts on alloxan-induced diabetic rats. In this study, various concentrations of leaves extract were tested against alloxan-induced diabetic rats. The efficacy of the extract was determined by investigating the biochemical parameters along with the determination of the antioxidant activity. The methanolic extracts were showed hyperglycemic effects at a concentration of 200 mg/kg and also possess potent antioxidant activity.

Govindan et al., (1999) studied the clinical efficacy of the *Solanum xanthocarpum* in bronchial asthma. A dose of 300 mg of the dose was used for 3 days investigated in the treatment of bronchial asthma. Its effect was compared with a standard asthmatic drug-like salbutamol and deriphylline. Measurement of the expiratory flow rate was determined and improvement of lung function was assessed. The scores of cough, breathlessness and sputum were decreased by these drug treatments. This drug showed the bronchodilator effect and No untoward effects were reported during the study. The study further confirms the traditional use of these herbs in bronchial asthma.

Nithya et al., (2018) studied the antibacterial activity and free radical scavenging activity of *Solanum xanthocarpum*. In this study, they described the whole phytochemical profile of the plant as well as the antibacterial and antioxidant properties of the plant. In phytochemical analysis, terpenoids, tannins, steroids and different chemical constituents were observed. Methanolic extract of the plant showed antibacterial activity and it was effective against Pseudomonas aeruginosa. About 3.2 to 6.9 µg/ml was the minimum inhibitory concentration observed. And minimum bacterial concentration was observed as 6.0 to 14.5 µg/ml. The remarkable antioxidant activity was observed in chloroform and methanol extract on the DPPH radical scavenging activity.

Oyinloye et al., (2019) investigated the role of *Solanum xanthocarpum*, in the treatment of cancer. In this study, a structure-based docking study was developed by using GLUT 4 towards exploring selected phytochemicals from the Solanum xanthocarpum which was used as a therapeutic agent in the treatment of cancer. Cancerous cells use more glucose than normal cells to proliferate and survive. Thus, the inhibition of glucose transporter-4-protein (GLUT4) expressed by solute carrier family-2-member-4-gene (Slc2a4) by selected phytochemicals from *Solanum xanthocarpum* regulates glucose consumption in malignant cells. Hence this drug candidate is served as the therapeutic agent for the treatment of cancer. In this method, seven identified potential inhibitors of GLUT4 were obtained from the plant *Solanum xanthocarpum* from the pubchem database. By using online tools like Molinspiration, PreADMET V.2.0 and Patchdock server, docking studies of the compounds were carried out along with GLUT4. The data demonstrated that five of the seven compounds match Lipinski's rule of five (RO5) for oral drug ability, whereas two only meet the threshold for RO5. Five of the compounds, on the other hand, are expected to be mutagens, while the remaining two are expected to be safe for the body. These data showed that Solanum xanthocarpum stigmasterol glucoside could be a promising medicinal agent with improved therapeutic efficacy than doxorubicin in the treatment of cancer via the inhibition of GLUT4.

Zhang et al., (2018) studied the formulation of gold nanoparticles of *Solanum xanthocarpum* extract and its evaluation and its in vitro effect against anticancer potential on nasopharyngeal carcinoma cells which is the subtype of the head and neck cancers. Gold nanoparticles (AuNPs) were synthesized from *Solanum xanthocarpum* (Sx) leaf extract using the reduction method. Various techniques were used in the determination of the gold nanoparticles like the x-ray diffraction method, dynamic light scattering method, and transmission electron method and energy dispersive X-ray analysis. It was found that there was a decline in both cell viability and colony formation in C666-1 cells upon treatment with Sx-AuNPs. Autophagy and the mitochondrial-dependent apoptotic pathway were found to be responsible for cell death. These nanoparticles combined with Sx can thus be used for in vivo applications and clinical research in the future due to their anticancer potential.

CONCLUSION

In the present review, various pharmacological activities have been reported which include anti-inflammatory activity, hepatoprotective activity, anti-oxidant property, hypoglycemic activity, cardiovascular activity, apoptosis-inducing activity, Mosquito larvicidal activity, anti-allergic activity, condensation activity, and suppression activity. Herbal medicines are in high demand these days due to their cost-effectiveness and user-friendliness. As a result, herbal formulations have received a lot of attention. *Solanum xanthocarpum* consists of the components like campeferol, diosgenin, campestrol, solasonine, and numerous useful alkaloids which have therapeutic potential against many diseases. Solasodine is the steroidal alkaloid that has a role in the production of sex hormones. Although the findings of this research are promising for the use of *Solanum xanthocarpum* as a multi-purpose therapeutic agent, the current literature has numerous limitations. Even though *Solanum xanthocarpum* has been used successfully in Ayurvedic medicine for ages, more clinical trials are needed to back up its medicinal usage. Furthermore, the plant's medicinal potential should be investigated when taken in conjunction with other herbal medicines.

REFERENCES

Alarcon L, Velasco J, Usubillaga A (2006). Determinacion de la actividad antibacteriana de los alcaloides presentes en los frutos verdes del *Solanum hypomalocophyllum* bitter. Rev Latinoamer Quim. 34: 13-21.

Ara I, Siddiqui BS, Faizi S, Siddiqui S (1988). Tricyclic diterpenoids from the stem bark of Azadirachta indica. J Natural Products. 51: 1054-1061.

Batabyal L, Sharma P, Mohan L, Maurya P, Srivastava CN (2007). Larvicidal efficiency of certain seed extracts against *Anopheles stephensi*, with reference to *Azadirachta indica*. J Asia-Pacific Entomol. 10: 251-255.

Bhutani KK, Paul AT, Fayad W Linder S (2010). Apoptosis inducing activity of steroidal constituents from *Solanum xanthocarpum* and *Asparagus racemosus*. Phytomedicine. 17: 789-793.

Chaturvedi PK, Bhui K, Shukla Y (2008). Lupeol: Connotations for chemoprevention. Cancer Letters. 263: 1-3.

Chiang CT, Way TD, Tsai SJ, Lin JK. (2007). Diosgenin, a naturally occurring steroid, suppresses fatty acid synthase expression in HER2-overexpressing breast cancer cells through modulating Akt, mTOR and JNK phosphorylation. FEBS letters. 581: 5735-5742.

Chungath JI, Nair PB (1989). Modified extraction method and determination of solasodine from *Solanum xanthocarpum* at different stages of fruit development. Ind Drugs. 26: 295-297.

Dixit VP (1980). Antifertility effects of Solasodine obtained from *Solanum xanthocarpum* berries in male rats and dogs. Department of Zoology, University of Rajasthan, Jaipur, India.

Dixit VP, Gupta RS (1982). Antispermatogenic/antiandrogenic properties of solasodine (C27H43O2N) obtained from *solanum xanthocarpum* berries on the male genital tract of dog (Canis-familiaris). A Histophysiological approach. Int J Androl. 5: 295-307.

Emmanuel S, Ignacimuthu S, Perumalsamy R, Amalraj T (2006). Antiinflammatory activity of *Solanum trilobatum*. Fitoterapia. 77: 611-612.

Fathima T, Joghee S, Akaash M (2019). *Solanum Xanthocarpum*: A Review. Int J Pharmacogn Chinese Med. 3: 000177.

Friedman M, McDonald GM, Filadelfi-Keszi M (1997). Potato glycoalkaloids: Chemistry, analysis, safety, and plant physiology. Critical Rev Plant Sci. 16(1):55-132.

Gabay O, Sanchez C, Salvat C, Chevy F, Breton M, et al. (2010). Stigmasterol: A phytosterol with potential anti-osteoarthritic properties. Osteoarthritis Cartilage. 18:106-116.

Goldberg B (1994). Alternative medicine: The definitive guide future medicine. Washington: Puyallup. 257.

Govindan S, Viswanathan S, Vijayasekaran V, Alagappan R (1999). A pilot study on the clinical efficacy of *Solanum xanthocarpum* and *Solanum trilobatum* in bronchial asthma. J Ethnopharmacol. 66: 205-210.

Govindan S, Viswanathan S, Vijayasekaran V, Alagappan R (2004). Further studies on the clinical efficacy of Solanum xanthocarpum and Solanum trilobatum in bronchial asthma. Phytotherapy Research: Int J Devoted Pharmaco Toxico Eval Nat Prod Deriva. 18: 805-809.

Gupta MP, Dutt S (1938). Chemical examination of the seeds of *Solanum xanthocarpum* (Schard & Wendel). Part II. The constituents. J Indian Chem Soc. 15:95-100.

Gupta RK, Hussain T, Panigrahi G, Das A, Singh GN, et al. (2011). Hepatoprotective effect of *Solanum xanthocarpum* fruit extract against CCl4 induced acute liver toxicity in experimental animals. Asian Pacific J Trop Med. 4: 964-968.

Gupta S, Mal M, Bhattacharya P (2005). Evaluation of hypoglycemia potential of *Solanum xanthocarpum* (Solanaceae) fruits in normal and streptozotocin induced diabetic rats. Eur Bull Drug Res 13: 51-55.

Heble MR, Narayanaswami S, Chadha MS (1968). Diosgenin and β-sitosterol: Isolation from *Solanum xanthocarpum* tissue cultures. Sci. 161: 1145.

Hussain T, Gupta RK, Sweety K, Khan MS, Hussain MS, et al. (2012). Evaluation of antihepatotoxic potential of Solanum xanthocarpum fruit extract against antitubercular drugs induced hepatopathy in experimental rodents. Asian Pacific J Trop Biomed. 2: 454-60.

Kadkade PG, Rolz C (1977). Steroidal alkaloids of *Solanum acculeatissimum*. Phytochemistry.

Kenny OM, McCarthy CM, Brunton NP, Hossain MB, Rai DK, et al. (2013). Anti-inflammatory properties of potato glycoalkaloids in stimulated Jurkat and Raw 264.7 mouse macrophages. Life Sciences. 92: 775-782.

Kumar N, Prakash D, Kumar P (2010). Wound healing activity of Solanum xanthocarpum Schrad. & Wendl. Fruits. 470-475.

Laurila J, Laakso I, Vaananen T, Kuronen P, Huopalahti R, et al. (1999). Determination of solanidine-and tomatidine-type glycoalkaloid aglycons by gas chromatography/mass spectrometry. J Agricultural Food Chem. 47: 2738-2742.

Mamta M, Pimpalgaonkar R, Dalei J (2016). Qualitative evaluation of phytochemicals and antifungal activity of *Solanum xanthocarpum* (Schrad. &Wendl.). J Pharma and Bio Sci. 11:99-104.

Mohan L, Sharma P, Srivastava CN (2005). Evaluation of *Solanum xanthocarpum* extracts as mosquito larvicides. J Environmental Bio. 26: 399-401.

Mohan L, Sharma P, Srivastava CN (2007). Comparative efficacy of Solanum xanthocarpum extracts alone and in combination with a synthetic pyrethroid, cypermethrin, against malaria vector Anopheles stephensi. Southeast Asian J Trop med Public Health. 38: 256.

Najmi AK, Pillai KK, Pal SN, Aqil M (2005). Free radical scavenging and hepatoprotective activity of jigrine against galactosamine induced hepatopathy in rats. J Ethnopharmacol. 97: 521-525.

Nithya M, Ragavendran C, Natarajan D (2018). Antibacterial and free radical scavenging activity of a medicinal plant *Solanum xanthocarpum*. Int J Food Properties. 21: 313-327.

Ondrusek MG, Kilts CD, Frye GD, Mailman RB, Mueller RA, et al. (1981). Behavioral and biochemical studies of the scopolamine-induced reversal of neuroleptic activity. Psychopharmacol. 73: 17-22.

Oyinloye BE, Adekiya TA, Aruleba RT, Ojo OA, Ajiboye BO (2019). Structure-based docking studies of GLUT4 towards exploring selected phytochemicals from Solanum xanthocarpum as a therapeutic target for the treatment of cancer. Curr Drug Discovery Tech. 16: 406-416.

Parmar S, Gangwal A, Sheth N (2010). *Solanum xanthocarpum* (yellow berried night shade): a review. Der Pharm Lett. 2: 373-383.

Patel PK, Patel MA, Vyas BA, Shah DR, Gandhi TR (2012). Antiurolithiatic activity of saponin rich fraction from the fruits of *Solanum xanthocarpum* Schrad. & Wendl.(Solanaceae) against ethylene glycol induced urolithiasis in rats. J Ethnopharmacol. 144: 160-70.

Paul AT, Vir S, Bhutani KK (2008). Liquid chromatography–mass spectrometry-based quantification of steroidal glycoalkaloids from *Solanum xanthocarpum* and effect of different extraction methods on their content. J Chromatography A. 1208: 141-146.

Pharmacopoeias (1999). The Ayurvedic Pharmacopoeia of India, Part-1. Government of India Ministry of Health and Family Welfare, Dept of I.S.M. & H. 1: 59-60.

Pol SV, Potdar V, Takke A, Takarkhede S, Bhoje RB (2016). Antibacterial Activity of Kantakari Seeds (*Solanum xanthocarpum*).

Poongothai K, Ponmurugan P, Ahmed KS, Kumar BS, Sheriff SA (2011). Antihyperglycemic and antioxidant effects of Solanum xanthocarpum leaves (field grown & in vitro raised) extracts on alloxan induced diabetic rats. Asian Pacific J Trop Med. 4: 778-85.

Rita P, Animesh DK (2011). An updated overview on *Solanum xanthocarpum* Schrad and Wendl. Int J Res Ayurveda Pharm. 2: 730-735.

Saiyed IZ, Kanga DD (1936). Chemical examination of the fruits of *Solanum xanthocarpum*. In Proceedings of the Indian Academy of Sciences-Section A. Springer India. 4: 255-260.

Sato Y, Latham Jr HG (1953). The Isolation of Diosgenin from *Solanum Xanthocarpum1*. J Ame Chem Soc. 75: 6067.

Siddique YH, Beg T, Afzal M (2008). Antigenotoxic effect of apigenin against anti-cancerous drugs. Toxicol *In-vitro*. 22: 625-631.

Singh OM, Singh TP (2010). Phytochemistry of *Solanum xanthocarpum*: An amazing traditional healer. 69: 732-740.

Tupkari SV, Saoji AN, Deshmukh VK (1972). Phytochemical study of *Solanum xanthocarpum*. Planta medica. 22: 184-187.

Vadnere GP, Gaud RS, Singhai AK (2008). Evaluation of anti-asthmatic property of *Solanum xanthocarpum* flower extracts. Pharmacologyonline. 1: 513-522.

Watt G (1893). A dictionary of the Economic products of India. W H Allen and Co. London Book Reviews. 6.

Weissenberg M, Levy A, Svoboda JA, Ishaaya I (1998). The effect of some Solanum steroidal alkaloids and glycoalkaloids on larvae of the red flour beetle, *Tribolium castaneum*, and the *Tobacco hornworm*, *Manduca sexta*. Phytochem. 47:203-209.

Zhang P, Wang P, Yan L, Liu L (2018). Synthesis of gold nanoparticles with Solanum xanthocarpum extract and their in vitro anticancer potential on nasopharyngeal carcinoma cells. Int J Nanomedicine. 13:7047.