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Solanum xanthocarpum (Yellow Berried Night Shade): A review

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ABSTRACT

Solanum xanthocarpum (Solanaceae) (SX) is an important medicinal herb in Ayurvedic medicine. Since, there are few articles on this plant, the present review is undertaken to summarize available data and compile all the updated information on its phytochemical and pharmacological activities. Various studies indicated that SX possesses antiasthmatic, hypoglycemic, hepatoprotective, antibacterial and insect repellent properties. Although the results are very encouraging and indicated that some of the constituents of the plant like solasodine and diosgenin are important therapeutically, the herb should be studied more extensively to confirm these results and reveal other potential therapeutic effects. Various traditional claims like immunomodulation, anti-inflammatory, antiallergic, antianaphylactic and antitumor effects of the plant are still remain to be validated scientifically. Clinical trials for the reported preclinical studies should be performed urgently to further validate the claims on humans.

Key Words: *Solanum xanthocarpum*, phramacological activities, phytochemistry, Solasodine, Traditional uses.

INTRODUCTION

Herbal medicines are being used by nearly about 80% of the world population, primarily in developing countries for primary health care [1]. Assessing the current status of health care system in adequacies of synthetic drugs is likely to be more glaring in the coming years. It has been reported that there has been an alarming increase in number of diseases and disorders caused by synthetic drugs prompting a switch over to traditional herbal medicine [2]. India has over 1, 08,276 species of bacteria, fungi, animals and plants already identified and described [3].

Out of these about 84% species constitutes fungi (21.2%), flowering plants (13.9%) and insects (49.3%).

Ayurveda is a traditional Indian Medicinal System practiced for thousands of years. Considerable research on pharmacognosy, chemistry, pharmacology and clinical therapeutics has been carried out on ayurvedic medicinal plants. Natural products, including plants, animals and minerals have been the basis of treatment of human diseases. The current accepted modern medicine or allopathy has gradually developed over the years by scientific and observational efforts of scientists. However, the basis of its development remains rooted in traditional medicine and therapies [4].

Selection of scientific and systematic approach for the biological evaluation of plant products based on their use in the traditional systems of medicine forms the basis for an ideal approach in the development of new drugs from plants. One such plant is *Solanum xanthocarpum* (SX) Schrad. & Wendl. (Family: Solanaceae) commonly known as the Indian night shade or Yellow berried night shade (English) and kantakari (Sanskrit). It is a prickly diffuse, bright green perennial herb, woody at the base, 2–3 m height, found through out India, mostly in dry places as a weed along roadsides and waste lands [5]. SX has held a place of some importance in the Hindu *Materia Medica*, primarily as an expectorant and antipyretic. Various medicinal properties are attributed to it, particularly in the treatment of asthma, chronic cough and catarrhal fever [6]. It is one of the members of the *dashamula* (ten roots) of the Ayurveda [7].

Taxonomic classification
Kingdom - Plantae
Subkingdom - Tracheobionta
Division - Magnoliophyta
Class - Magnoliopsida
Subclass - Asteridae
Order - Solanales
Family - Solanaceae
Genus - Solanum

Botanical description

Synonyms

Latin:	*Solanum surattense*, Syn. *S. Xanthocarpum*
Sanskrit:	Kantkari, Nidigdhika
Hindi:	Kateri, Kattay
Gujarati:	Bhoringni, Bhonya-ringani
Tamil:	Kantankattiri
Malayalam:	Kantkariccunta, Kantakarivalutana, Kantankattiti
Telugu:	Callamulaga, Pinnamulaka, Nelamulaka, Vakudu
Kannad:	Nelagulle

Geographical Source

It occurs throughout India, in dry situations as a weed along the roadsides and wastelands. It is naturally propagated by seed in waste lands. It is also distributed in Ceylon, Asia, Malaya, Tropical, Auastrana and Polynessia [8].

Morphology

A very prickly diffuse bright green perennial herb, somewhat woody at the base; stem is somewhat zigzag; branches are numerous, the younger ones clothed with dense stellate tomentum; prickles are compressed, straight, yellow, glabrous and shining, often exceeding 1.3 cm. Leaves are usually 5-10 in numbers and 2.5-5.7 cm in length, ovate or elliptic, sinuate or sub pinnatified, obtuse or sub acute, stellately hairy on both sides, sometimes becoming nearly glabrous in age, armed on the midrib and often on the nerves with long yellow sharp prickles, base usually rounded and unequal-sided; petiole 1.3-2.5 cm long, stellately hairy. The berries are green and white strips when young but yellow when mature. They are 1.3-2 cm in diameter, yellow, or white with green veins, surrounded by the enlarged calyx. Seeds are 2.5 mm in diameter and glabrous. Calyx is nearly 1.3 cm long, densely hairy and prickly; tube short, globules. Lobes are 11 mm long, linear-lanceolate, acute and hairy outside. Filaments are 1.5 mm long, glabrous; anthers 8 mm long, oblong lanceolate, opening by small pores. Ovary is ovoid, glabrous; style glabrous [9].

Traditional uses

In ancients Ayurveda, plant is described as pungent, bitter, digestive, alternative astringent. Stems, flowers, fruits are bitter, carminative. Root decoction used as febrifuge, effective diuretic and expectorant [10]. Charaka and Sushruta used the extract of entire plant and fruits in internal prescription for bronchial asthma, tympanitis, misperistalsis, piles and dysuria and for rejuvenation. *Kantkari Ghrita* of *Charaka* is specific for cough and asthma [11]. Linctuses prepared from the stamens of flowers is prescribed for chronic cough in children (Bangasena).

The whole plant is used traditionally for curing various ailments. Decoction of the plant is used in gonorrhea; paste of leaves is applied to relieve pains; seeds act as expectorant in cough and asthma; roots are expectorant and diuretic, useful in the treatment of catarrhal fever, coughs, asthma and chest pain [12]. The plant is also known to have pest repellent properties and used as a contact poison and mollusicide. Roots are one of the constituents of well known Ayurvedic preparation "*Dasmul Asava*" and used as an expectorant, cough, asthma, and chest pain in Ayurvedic medicine [11].

Fruits are edible and used by the local people as folk medicines in treating throat infections and other inflammatory problems [13]. The stem, flowers and fruits are prescribed for relief in burning sensation in the feet accompanied by vesicular eruptions. The antispasmodic, antitumor, cardiotonic, hypotensive, antianaphylactic and cytotoxic activities are also reported [14]. Fruit juice is useful in sore throats and rheumatism. A decoction of the fruits of the plant is used by tribal and rural people of Orissa, India for the treatment of diabetes [15]. The fruits are eaten as an anthelmintic and for indigestion.

Phytochemistry

Chemical examinations of berries of SX were initially done by Saiyed and Kanga, (1936) [16] which led to the isolation of glycoalkaloid, solasonine. From the non alkaloidal portion, a glycoside of β-sitosterol with galactose as a sugar moiety has been obtained along with two phenolic substances, which could be identified as methyl caffeate and caffeic acid [6].

The fruits are reported to contain several steroidal alkaloids like solanacarpine [17] and solamargine [6]. Other constituents like caffeic acid coumarins like aesculetin and aesculin [18], steroids carpesterol, diosgenin, campesterol, daucosterol and triterpenes like cycloartanol and cycloartenol were reported from the fruits [19]. Steroidal glycoalkaloids are naturally occurring, secondary plant metabolites that are formed in a number of foods including potatoes, tomatoes, and eggplants [20]. Although they are reported to be potentially toxic, glycoalkaloids and hydrolysis products without the carbohydrate side chain (aglycons) also have beneficial effects. These include lowering of cholesterol [21], protection against infection by Salmonella typimurium [22] as well as against cancer [23], and potentiation of general anesthetics that act by inhibiting cholinesterase [24] and of a malaria vaccine [25]. Solanidine, but not the parent glycoalkaloids, exhibited estrogenic activity in an in vitro assay [26]. Structures of some isolated phytoconstituents from SX are shown in Figure 1.

The fruit of SX contains alkaloid saponins which can be extracted in alcohol and have a heart-stimulating function [27]. The detailed study on this plant resulted in the isolation of solasonine and solasodine [16], ß-sitosterol [19], and carpesterol [28].

The fruits contained 20.71% of dry seeds, 4.62 of pericarp and 74.67 percent of moisture. The powdered seeds were extracted with benzene and yielded 19% of greenish-yellow oil which did not contain nitrogen or sulphur. The composition of the oil was calculated as oleic acid, 42.93; linolic acid, 36.18; palmitic acid, 5.37; steric acid, 9.77; arachidic acid, 0.35, and unsaponifiable matter, 1.2 percent [17].

Solasodine

SX has a high concentration of solasodine alkaloid, a spiroketal alkaloid sapogenin with a heterocyclic nitrogen atom, which is the starting material for the manufacture of cortisone and sex hormones [29].

The berries are the main source of solasodine and diosgenin. Solasodine is N-analogue of diosgenin and used as a steroidal precursor in the steroid drug industry for the manufacture of corticosteroids, antifertility drugs, anabolic steroids etc. It is present in the form of a glycoside in most of the berries of the plant belonging to the genus *solanum* and the glycoalkaloids are variously known as solasonine, solamargine etc. with the common spiro aminoketal alkaloid or aglycon namely solasodine. The solasodine content of the berries of SX is reported to vary from 1.1% to 4.6% [30] depending apparently on climatic and soil conditions. It has been observed that berries collected in autumn (September, October) yielded only solasonine and solamargine without any trace of solasurine which was obtained from the material collected in summer (May, June). The solasodine content of the unripe berries was 1.7% (on dry weight basis) as against 0.75% noted for the ripe berries.

Solasodine has been estimated by various methods by many workers viz. gravimetric, non-aqueous, potentiometric, Chromatography, Colorimetric and even RIA. A number of analytical methods like high performance thin-layer chromatography (HPTLC) [31], and high-performance liquid chromatography (HPLC) [32], capillary electrophoresis, gas chromatography (GC) [33], are available for determination of solasodine from its plant. Solasodine does not have a conjugated double bond in its structure [34].

S. Emmanuel et al. (2006) reported satisfactory content of solasodine (0.84%) in the plant. Further, they reported that the control of temperature, time of extraction and concentration of hydrochloric acid has some influence on the percentage recovery of solasodine. In no case extraction, hydrolysis, basification and purification temperature should be high throughout the process of estimation as it may affect in actual recovery of solasodine due to over heating [35].

Pure white crystals of solasodine could be obtained with 196-197°C m.p. Solasodine is a nitrogenous analogue of diosgenin which can be converted to progesterone a steroidal sex hormone used in the oral contraceptive industry [35].

The studies of S. Emmanuel, (2006) revealed that solasodine showed anti-inflammatory activity against carrageenan induced paw oedema in rats. The tested extract and its constituent solasodine showed significant reduction of the inflammatory reaction from 19.5 to 56.4% [35].

M. R. Heble et al. (1968) reported the isolation and identification of ß-sitosterol and diosgenin from callus tissues of SX. Chemical examination of SX berries also resulted in the isolation of diosgenin. Although only trace amounts of the steroidal alkaloid solasonine and solanine were detected earlier, the tissue cultures of SX have yielded ß-sitosterol and diosgenin in quantities much higher than that obtained from the growing plant [28].

Carpesterol

Carpesterol was the first compound isolated from the lipid fraction of plant, more than three decades ago no structural studies of the sterol have been reported. Because it was hoped that a structural knowledge of carpesterol would shed some light on the biogenetic pathway leading to solasodine ,which is the major alkaloid accompanying carpesterol in SX and commonly found among many other *solanum* species.

Saiyed and Kanga (1936) isolated the substance carpesterol along with a steroidal alkaloid glycoside [16]. Subsequent investigations of extracts from SX showed the presence of diosgenin [19, 28], and β-sitosterol.

Jolly et al. **(**1989) have reported the variation in the solasodine content, at different stages of fruit maturity viz. berries when green in color, color changing from green to yellow color. It was concluded that the berries of SX in the initial stages of fruit development are very small, green in color with white blotched stripes [36]. On growing, it develops yellow color which signifies the beginning of ripening. On ripening it attains yellow color. Berries on further standing in the plant becomes deep yellow in color, at which stage the stalk through which the berries are attached turns brown in color from the original green. During fruit development or maturity, an

associated change in the steroidal glycoalkaloid content and therefore in the steroidal alkaloid content was observed. The colorimetric method was used for the determination of the solasodine content. Solasodine forms yellow colored complex with methyl orange extractable in chloroform. It gave maximum absorbance at 425 nm.

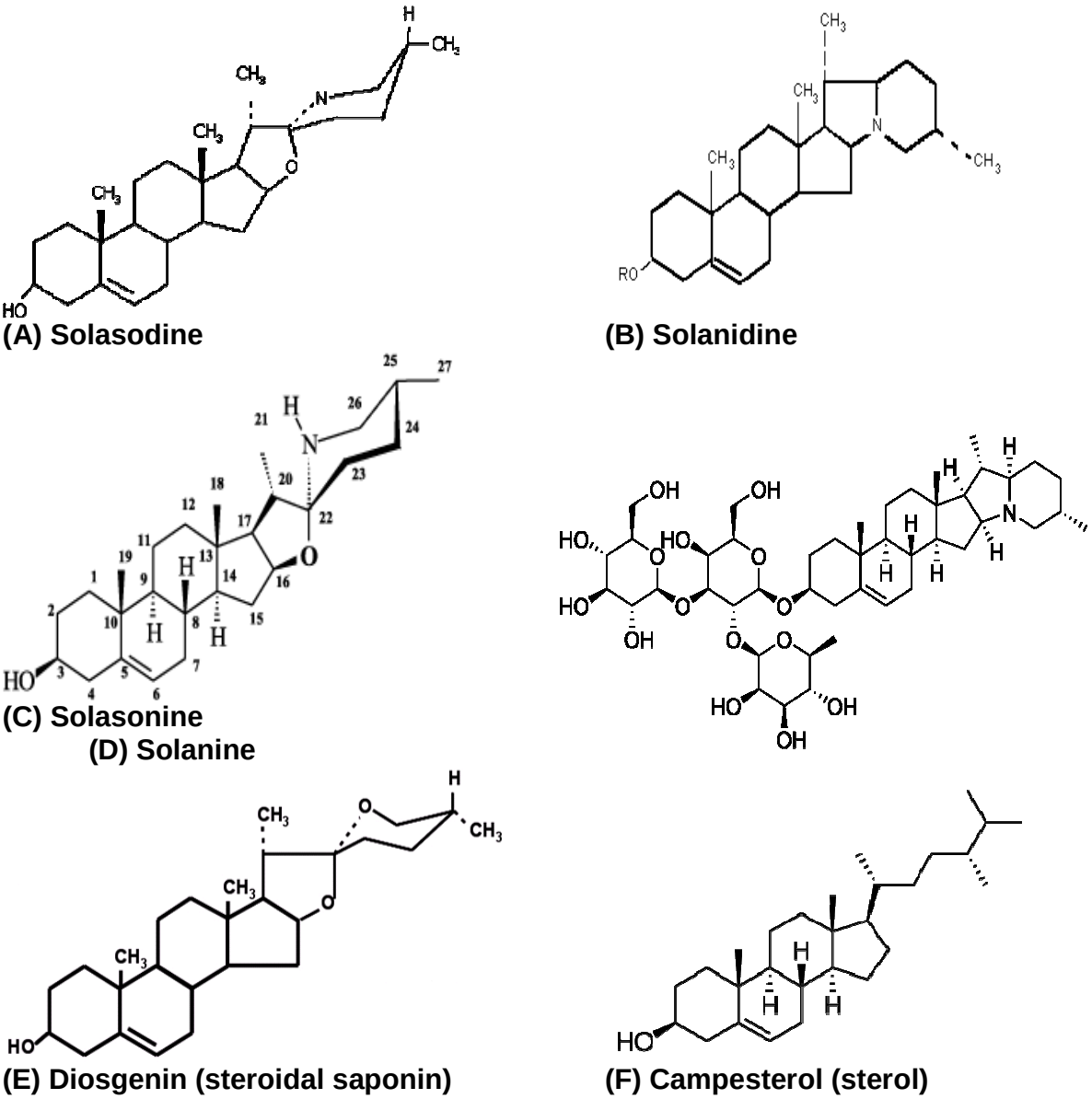

Figure 1. Structures of some phytoconstituents isolated from *Solanum xanthocarpum*

From berries collected during various months from the same area, it was greatest when berries are yellow in color (i.e. when the berries are ripe) [36].

From the fruit extract of SX, cycloartanol, cycloartenol, sitosterol, stigmasterol, campesterol, cholesterol, sitosteryl glucoside, stigmasteryl glucoside, solamargine, and β-solamargine were identified and an isolated steroid was identical with 4α-methyl-(24R)-ethylcholest-7-en-3β-ol synthesized from carpesterol.

Pharmacological actions

Antiasthmatic properties

Bronchial asthma is an inflammatory disorder of the airways characterized by various airway obstruction, airway eosinophilic inflammation and bronchial hyper responsiveness [37] and is a global health problem that results from a complex interplay between genetic and environmental factors [38]. Among several respiratory diseases affecting man, bronchial asthma is the most common disabling syndrome. Nearly 7–10% of the world population suffers from bronchial asthma. Despite the availability of a wide range of drugs, the relief offered by them is mainly symptomatic and short lived. Moreover the side effects of these drugs are on going to identify effective and safe remedies to treat bronchial asthma.

A pilot study on the clinical efficacy of SX and *Solanum trilobatum* in bronchial asthma were undertaken to prove the significant use of herbs in treatment of asthma [7]. Major literature data supports use of whole plants. Gautam et al. (2008) evaluated the therapeutic effect of ethanolic extract of SX i.e. asthma relieving or antihistaminic, antiallergic property [10].

Gautam et al. (2008) studied effects of SX extract on some of the parameters like smooth muscle relaxation, and antagonism of asthma mediators such as histamine, eiosinophils and protection against mast cell degranulation which seemed to be prominent in pathophysiology of asthma [10]. Further they showed that ethanol extract of SX shown a significant antihistaminic activity in histamine induced contraction in goat tracheal chain preparation. Thus, the significant inhibition of histamine induced contractions produced by ethanol extract of SX flower on isolated goat tracheal chain preparation indicates that the SX flower has antihistaminic (H_1-receptor antagonist) action. While screening the all three extracts of flowers of SX, results were indicative that only ethanolic extract of SX at a dose of 50 and 100 mg / kg reduced milk-induced eiosinophilia of statistical significance. SX at a dose of (50-100 mg/kg, i.p) showed significant mast cell stabilization as compared to standard drug Disodiumchromoglycate (DSCG).

SX is widely used by practitioners of the Siddha system of medicine in southern India to treat respiratory diseases [15]. The powder of whole dried plant or a decoction is used for this purpose. Govindan et al. (1999) showed that treatment with SX improved the pulmonary functions to a significant level in patients suffering from mild to moderate asthma. Subjective relief from asthmatic symptoms was reported by the patients an hour after administration of SX powder. The effect lasted for about 6–8 h. However, responses observed were apparently less when compared to that of deriphilline or salbutamol. A decrease in forced expiration volume and peak expiration flow rates are indicative of both large and small airway obstruction and muscle power [39]. The dose of SX was well tolerated and no untoward effects were reported. SX is a safe medicine in the traditional system and has been used by mankind over many centuries. It was suggested that relief from the symptoms of bronchial asthma produced by SX may be due

to:(a) a bronchodilator effect, (b) reduction in the bronchial mucosal edema, and/or (c) reduction in the secretions within the airway lumen.

Hypoglycemic activity

The Kondh tribes of Dhenkanal district of Orissa, India use the hot aqueous extract of the matured fruits as a traditional medicine for the treatment of diabetes mellitus.

The aqueous extract showed significant hypoglycemic effect in both normal and streptozotocin induced diabetic rats at dose of 100 and 200 mg/kg. The activity showed by aqueous extract was comparable to that of standard oral hypoglycemic agent glibenclamide. The experimental results indicated that it exhibited a potent blood glucose lowering property both in normal and streptozotocin induced diabetic rats. The LD_{50} of the extract was found to be high indicating high margin of safety [40].

Hepatoprotective activity

Jigrine is a polypharmaceutical herbal formulation containing aqueous extracts of 14 medicinal plants including SX and used for liver ailments. A. K. Najmi et al. [2005] investigated the DPPH-free radical scavenging activity, hepatoprotective and antioxidant activity of Jigrine against galactosamine induced hepatotoxicity in rats [41].

Cardiovascular effects

Pasnani JS (1988) reported that Abana, a polyherbal formulation containing SX causes: (i) A direct sensitization of the atrium through an increase in permeability to Ca^{2+} and (ii) an effect similar to withdrawal of chronic ISO administration, i.e. down regulation of beta adrenoceptors [42].

Antifilarial effect

Lalit Mohan et al. (2006) reported the larvicidal potential of crude extracts of SX and suggested its suitability as an ecofriendly, effective larvicide in the management of mosquito populations and in limiting the outbreak of various vector borne epidemics [43].

Mosquito larvicidal effect

The plant has been used in the various fields of pest management [45] but it is not exploited in vector control. The fruit extracts of SX revealed larvicidal activity against *An. stephensi* and *Cx. Quinquefasciatus* and one culicine species *Ae. aegypti* [46]. Volatile oil obtained from SX exhibited repellency against mosquito *Cx. quinquefasciatus* at a very lower concentration than those of the plants studied earlier. The lethal concentrations of fruit extract at LC_{50} and LC_{90} levels against *An. culicifacies*, *An. stephensi* and *Ae. aegypti* were determined as 0.112 and 0. 258, 0.058 and 0.289 and 0.052 and 0.218% respectively. The root extract is also effective against anopheline and culicine mosquito species, though at higher concentrations in comparison to fruit extract [44]**.**

Miscellaneous activities

Dixit VP (1982) reported antiandrogenic activity of solasodine, an alkaloidal constituent of the plant [47]. Further study showed antifertility effects of solasodine in male rats and dogs [48].

Carpesterol and four steroidal glycosides isolated from methanol extract of SX fruits exhibited inhibitory effects on the radial growth of *Aspergillus niger* and *Trichoderma viride* [49]. Methanolic extract from dried fruit tissues of SX showed antifungal activity against *A. brassicae*. The methanolic extract of SX aerial parts significantly and dose-dependently suppressed the frequency of acetic acid-induced abdominal constrictions in mice.

SUMMARY AND CONCLUSION

Alternative system of medicine is a major component of health care globally and many healthcare providers and organizations are being forced to consider integrating them into their practice and treatment guideline [50].

The extensive survey of literature revealed that SX is an important source of many pharmacologically and medicinally important chemicals, especially steroidal hormone solasodine and other chemicals like solasonine, campestrol, campeferol, diosgenin and various useful alkaloids. The solasodine is the most studied chemical constituent of SX which has a role in the production of sex hormones. The plant is extensively studied for the various pharmacological activities like antiasthmatic, hepatoprotective, cardiovascular, hypoglycemic and mosquito repellent properties. Various traditional claims like immunomodulation, hypolipidemic, antibacterial, sexual behaviour, tolerance and dependence is not studied till the date and needs attention in this area to explore further medicinal values of this plant. Although the results from this review are quite promising for the use of SX as a multi-purpose medicinal agent, several limitations currently exist in the current literature. While SX has been used successfully in Ayurvedic medicine for centuries, more clinical trials should be conducted to support its therapeutic use. Moreover, the therapeutic potential of the plant should also be checked when used in combination with other herbal drugs.

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