

## Phyto-Pharmacological Review of *Solanum xanthocarpum* Schrad and Wendl

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### ABSTRACT

*Solanum xanthocarpum*, Schrad and Wendl (family: solanaceae) commonly known as the kantakari or Indian night shade is known for its invariable medicinal properties in traditional system of medicines. Plant is found throughout India mainly at dry and waste places as weed along roadsides. Phytochemically, *S. xanthocarpum* contain a number of phytoconstituents including alkaloids, sterols, saponins, flavonoids and their glycosides and carbohydrates, fatty acids, amino acids etc. Large medicinal value of the plant is mainly due to presence of steroidal alkaloids, mainly, solasodine and solasonine and many others. Scientific studies report antiallergic, antiasthmatic, antifertility, nephroprotective activity, immunomodulatory activity, cardiogenic activity and anti-urolithic properties. of plant. Plant is also one of the components of several traditional herbal formulations, dashmularista and kanakasava. In vitro and in vivo experimental studies of *S. xanthocarpum* provide evidence for traditional use of plant as an antiasthmatic, immunomodulatory and diuretic drug.

**Keywords:** *Solanum xanthocarpum*, kantakari, traditional, solasodine, antiallergic, immunomodulatory.

### INTRODUCTION

The genus *Solanum* is the largest group of angiosperm plants found under the umbrella of family Solanaceae. The genus contains more than 2,000 species, ranging from food crops to various ornamentals and medicinal species. The plants are known to grow wild throughout world but some globally important species such as *S. lycopersicum* (tomato), *S. tuberosum* (potato), *S. melongena* (eggplant), *S. americanum*, *S. villosum*, *S. incanum*, *S. surrattense*, *S. nigrum* L are cultivated for their nutritive food and medicinal value with Dioscoride, one of the first to record their medicinal properties<sup>1</sup>. Amongst these, *Solanum xanthocarpum* Schrad and Wendl commonly known as the kantakari or Indian night shade is known for its invariable medicinal properties. Plant is found throughout India at every soil, mainly dry and waste places and as weed along roadsides<sup>2,3</sup>.

#### Scientific classification

Kingdom	:	Plantae
Phylum	:	Pinophyta
Class	:	Pinopsida
Order	:	Pinales
Family	:	Pinaceae
Genus	:	<i>Solanum</i>
Species	:	<i>xanthocarpum</i>
Binomial name	:	<i>Solanum xanthocarpum</i> Schrad and Wendl.
Synonym	:	<i>Solanum surattense</i> Burm.

#### General description

The plant is very prickly diffused perennial herb with woody zigzag stem covered with dense and tomentose hairs (Figure 1). Prickles are straight, compressed, and

shining. Leaves are oval elliptical, sinuate or sub-pinnatifid, hairy, covered with prickles. Petiole is long, hairy and prickly. Flowers are small, with lateral cymes, purple corolla and short calyx. Fruit is yellow or white berries, with green veins, surrounded by calyx. Seeds are glabrous<sup>3</sup>.

#### Ethnomedicinal/traditional uses

Kantakari is bitter and pungent with hot and dry potency. It is commonly used in bronchial asthma, cough, worms etc. The fruits facilitate the seminal ejaculation, alleviate worms, itching and fever and reduce fats<sup>3</sup>. Mukundara tribals of Rajasthan use paste of the roots in hernia. Leaves are applied locally to treat muscular pain and juice mixed with black pepper is used in rheumatism. The paste applied on painful joints in arthritis, reduces pain and swelling<sup>4</sup>.

Roots of the plant are an ingredient of dashmularista. Decoction of root is given with long pepper and honey, in cough and catarrh, and with rock salt and asafoetida in spasmodic cough. The powder plant with oil is used externally to alleviate nasal disorders. The dried fruits are smoked in the form of cigarettes and smoke held up in the mouth cures dental infections. The fumigation of kantakari is known to be useful in treating piles. In Srilanka and Thailand, roots are used in cough and fever.

#### Reported phytoconstituents

*Solanum xanthocarpum* contains alkaloids, sterols, saponins, flavonoids and their glycosides and carbohydrates, fatty acids, amino acids etc. Steroidal alkaloid solasodine is the principal alkaloid present in the whole plant, fruits, leaves, seeds. Other than the principle steroidal alkaloids present in the fruits are solamargine,  $\beta$ -solamargine, solasonine, solanocarpidine, solanocarpine,

solasodine, diosgenin<sup>5</sup>. whereas seeds contain solanocarpine, solanocarpigenin.

Steroids constituents of fruits are campesterol, carpesterol 4-demethyl, doucosterol,  $\beta$ -sitosterol, stigmasteol, and stigmastertol-3-O-beta-D-glucose and tritreprenoids, cholest-7-en-3-beta-ol-4-alpha-methyl-24(R)-ethyl, cholest-7-en-3-beta-ol-4-alpha-methyl-25(R)-ethyl; cholest-7-en-6-one-3-beta-22-epsilon-dihydroxy-4-alpha-methyl-24-epsilon-ethyl-5-alpha, cholest-7-en-3-beta-22-epsilon-dihydroxy-4-alpha-methyl-24-epsilon-ethyl-5-alpha, cycloartanol.

Small quantities of isochlogenic acid, neochronogenic acid, chromogenic acid, caffeic acid and a nonsaponifiable compound, carpesterol have been isolated from fruits. Coumarins namely, esculetin, esculin and scopoletin are present in fruits, leaves and roots. Caffeic acid and oleanolic acid were also isolated from the roots of the plant<sup>6</sup>. Volatile oil constituents in fruits were identified as benzyl benzoate (21.7%) and (E,E)-geranyl linalool (12.6%); stem oil was dominated by palmitic acid (28.9%), heptacosane (12.8%) and linoleic acid (10.1%); while solavetivone (22.9%), palmitic acid (21.0%), and linoleic acid (8.2%) were major components of the roots, whereas heptacosane (20.0%) was the major component of the leaf oil.

Fruits possess higher quantities of alkaloids than other parts. Small amounts of copper, iron, lead, cadmium and zinc have also been assayed in the plant. Khasianine another bioactive steroidal alkaloid have been isolated from the *S. xanthocarpum*<sup>7</sup>.

#### Reported biological activities

##### Anti-fertility activity

In laboratory animals, chronic administration of solasodine isolated from *S. xanthocarpum* berries resulted in reduction of spermatozoa count, total protein, sialic acid and glycogen content of epididymis rendering animals infertile for long period. Treatment caused increased levels of cholesterol and phospholipids. Antifertility effects of solasodine were also observed in Rhesus monkeys<sup>8</sup>. In female rats, aqueous suspension of *S. xanthocarpum* seed powder at 100 and 150 mg/kg doses for 30 days reduced organ weight of genital organs and fertility and histopathological changes in the ovary and uterus<sup>9</sup>.

##### Antipyretic effects

Single dose administration of solasodine reduce body temperature in pyrago and DNP model of pyrexia induced in animals and normal rats possibly through central effect.

##### Anticancer activity

Oral administration of SXC aqueous leaves extract treatment at a dose of 150mg/kg b.w. to Diethylnitrosamine (DEN) induced hepato carcinogenesis in male Wistar albino rats prevented tumour incidence and restored the elevated activities of liver marker enzymes and antioxidant status to near normal with decreased lipid peroxide levels. In Hep3B cell, treatment with solamergine, exhibited cell death by apoptosis at G<sub>2</sub>/M stage of cell cycle and upregualtion of TNFR -I and TNFR-II (TNF- I and II)<sup>10</sup>.

##### Snail killing activity

In a study, 0.2 mg/l solution of  $\alpha$ -solamergine extracted from fruits of *S. xanthocarpum* were found to kill Oncomelania snails significantly (100%) at 28°C<sup>11</sup>.

##### Anti-inflammatory activity

Lupeol, one of the constituents of *S. xanthocarpum* exhibited anti-inflammatory effects in experimental models targeting at multiple receptors nuclear factor kappa (NF $\kappa$ B), Cflip, Fas, Kras, phosphatidylinositol-3-kinase<sup>12</sup>. Stigmasterol, carpesterol and diosgenin also showed similar effects contributing towards antiinflamamtory effects of the plant<sup>13</sup>. Acute treatment didnot show anti-inflammatory activity against carrageenan and histamine induced paw edema. Ethanol extract of *S. xanthocarpum* exhibited acute, sub-acute and chronic anti-inflammatory activity by inhibiting carrageenan and dextran-induced oedema and cotton pellet granuloma<sup>14,15</sup>. Granuloma formation in cotton pellet granuloma was suppressed in rat model.

##### Hepatoprotective activity

In one investigation, *S. xanthocarpum* extracts as evaluated for hepatoprotective activity using CCl<sub>4</sub> induced hepatotoxicity in rats showed significant increased levels of enzyme which indicates the antioxidant activity of the plant<sup>16</sup>.

##### Anti-hyperglycemic activity

Alkaloids and flavonoids present in *Solanum xanthocarpum* exhibit hypoglycemic activity mediated through increased pancreatic secretion of insulin from existing  $\beta$ -cells and hence associated for its potential of beta cell regeneration of pancreas<sup>17</sup>. Methanol extracts of leaves of *S. xanthocarpum* (field grown and *in vitro* raised) at concentration of 200 mg/kg b.w exhibited promising anti hyperglycemic activity in alloxan induced diabetic rats and potent antioxidant activity<sup>18</sup>. In a study, ethanolic extract of *S. xanthocarpum* schrad & wendl upregulated Glu-4 and PPAR  $\gamma$  gene expression in L6 cell lines. Leaf extract of *S. xanthocarpum* possess strong potential to reverse alloxan-induced hyperglycemia by normalizing levels of antioxidant enzymes including SOD, Catalases, superoxide dimutases, glutathione peroxidases, lipid peroxides<sup>18</sup>.

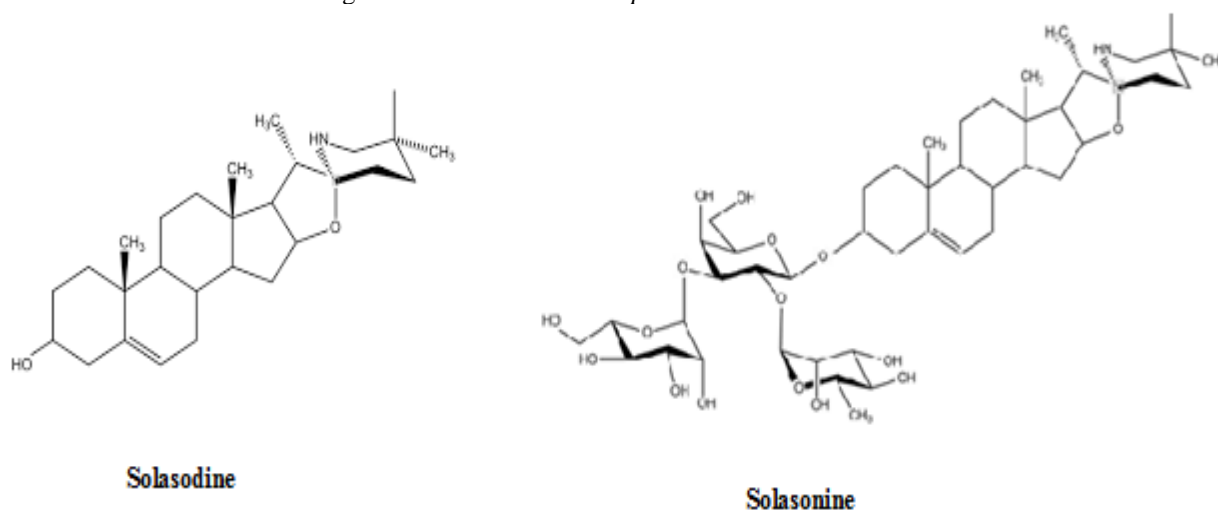
##### Anti-histaminic activity

Ethanolic extract of *Solanum xanthocarpum* at 50 and 100 mg/kg produced significant reduction in milk induced eosinophilia and mast cell degranulation compared to standard drugdisodium cromogylate. Further, the extract was also found to inhibit histamine induced contractions in goat tracheal chain preparation<sup>19</sup>.

##### Anti-asthmatic and anti-allergic activity

Apigenin, a constituent of *S. xanthocarpum* reversed AHR, inflammatory cell count in serum and BALF in ovalbumin induced asthma model of mice<sup>20</sup>. Ethanolic extract of *S. xanthocarpum* prevented histamine and acetylcholine induced bronchoconstriction in guinea pigs demonstrating anti-asthmatic action of the plant<sup>21</sup>. In another study, methanolic extract of *S. xanthocarpum* roots inhibited of leukotriene-B<sub>4</sub> synthesis in bovine polymorphonuclear leukocytes.

##### Hepatoprotective activity

Figure 1: *Solanum xanthocarpum* Schrad and Wendl.Figure 2: Structures of some phytoconstituents present in *S. xanthocarpum*.

Oral administration of ethanol extract of *S. xanthocarpum* (EESX at 200 mg and 400 mg/kg) leaf in paracetamol induced hepatic damaged in experimental rats showed significant dose dependent reversal of serum enzymes, total protein and bilirubin levels. The extract provided protection against morphological and histopathological changes<sup>21</sup>. Acting at 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS), 2,2-diphenyl-1-picrylhydrazyl (DPPH) powerful radicle scavenging property and SOD, CAT, GSH, and GST ALT, ALP LDH, AST, hepatoprotective effects of *S. xanthocarpum* against CCl<sub>4</sub>-induced hepatotoxicity has been proved. Hepatoprotective effect of *S. xanthocarpum* against antitubercular drugs induced hepatotoxicity has been evaluated in rodents<sup>22</sup>.

#### Immunomodulatory activity

Methanol extracts of fruits of *S. xanthocarpum* showed pronounced immunoprotective activity in cyclophosphamide induced immunosuppression model of albino mice. The effects may be mediated by increasing the depleted levels of total WBC count and RBC, %Hb, and % neutrophils adhesion<sup>23</sup>.

#### Larvicidal activity

In an experiment, methanol extracts from fruits without seeds, whole yellow ripe fruits and seeds of the *S. xanthocarpum* evaluated against larvae of *Anopheles*

*culicifacies*, *Anopheles stephensi*, *Aedes aegypti* and *Culex quinquefasciatus* showed its efficacy against larvae decrease with duration of storage of the extracts and plant<sup>24</sup>.

#### Nephroprotective activity

The ethanolic extract 400 mg/kg treated rat group showed significant elevation in body weight and urine volume output with decrease in urine creatinine and albumin, serum creatinine and urea compared to toxic control group<sup>25,26</sup>. In another study, nephroprotective potential of *Solanum xanthocarpum* fruit extract were proved against gentamicin induced nephrotoxicity and renal dysfunction.

#### Antiurolithic activity

Oral administration of *S. xanthocarpum* fruit extract in ethylene-glycol-induced urolithiasis in rats with decrease in hyperoxaluria, calcium, uric acid and improvement of renal function and producing antioxidant effects and mediated possibly by CaOX crystal inhibition, diuretic, antioxidant and maintaining balance between stone promoter and inhibitor constituents<sup>27</sup>. In a study, antiurolithic activity for solasodine and solasonine where only solasonine revealed better natriuretic activity compared to solasodine<sup>28,29</sup>.

#### Cardiotonic activity

In a preliminary study by Samuel and Henry, infusion of fruits of *Solanum xanthocarpum* was evaluated for

cardiotonic apotntial in *in vitro* study using isolated frog heart. Results showed better cardiotonic property of *Solanum xanthocarpum* compared to digoxin.

#### Anthelmintic activity

The aqueous and ethanol extracts of *S. xanthocarpum* at higher concentration of 100mg/ml. killed worms significantly compared to piperazine citrate especially confirming the anthelmintic activity against the Indian earth worm (*Pheretima Posthuma*)<sup>30</sup>.

#### Anti-oxidant

Oral administration of *S. xanthocarpum* leaf extract exhibited inhibition of superoxide dismutase, catalase, lipid peroxidase enzymes etc, in diabetic rats (Sridevi *et al.*, 2007). Root extract of *S. xanthocarpum* exhibited significant free radical scavenging activity in DPPH radical scavenging assay and 40-50% lipid peroxidation inhibition (LPOI) in rat liver homogenate<sup>31</sup>. In another study, ethanol extracts of leaves and stem of *S. xanthocarpum* showed strong antioxidant activity in DPPH radical scavenging<sup>29</sup>. Dose dependent extracts DPPH free radical scavenging activity and LPOI and metal ion chelating activity of *Solanum xanthocarpum* various extracts. Better activity was obtained for polar extracts, tannins and terpenoids enriched extracts produced better results compared to flavonoids enriched<sup>31</sup>.

#### Anti-bacterial activity

Among methanol, acetone, petroleum ether and aqueous, highest antibacterial activity was shown by methanol and acetone extracts compared to other solvents against all the bacterial species, *E. coli* and least against *K. pneumonia*<sup>32</sup>. Alcohol, acetone and petroleum ether extract of stem, leaf and fruits of plant exhibited potent antibacterial activity against *K. pneumonia* and *S. typhi*<sup>33</sup>. Methanolic fruit extracts of *S. nigrum* and *S. xanthocarpum* at 5, 10 and 15 mg/ml showed significant inhibition against bacteria and fungi less than ampicillin or amphotericin B<sup>34</sup>. *In vitro* investigation of anti-*Helicobacter pylori* activity of synthesized silver nanoparticles of methanol extract from *Solanum xanthocarpum* berry against 34 clinical isolates and two reference strains of *Helicobacter pylori* by the agar dilution method effectively inhibited the growth of *H. pylori*, indicating a stronger anti-*H. pylori* activity than that of standard AgNO<sub>3</sub> or MNZ, being almost equally potent to tetracycline and less potent than amoxycyline and CLA<sup>34</sup>.

#### Anti-fungal activity

Hexane extract of *S. xanthocarpum* leaves showed effective inhibition of growth of *C. albicans* with maximum zone of inhibition (500 µg/ml) and minimum (100 µg/ml) concentration of hexane extract of *S. xanthocarpum* against *C. albicans*. Aqueous extract of the plant leaves did not show any effects against any of the fungal species<sup>35</sup>.

#### Skin diseases

In a study, both topical (10%) and oral (200 and 400mg/kg p.o.) administration of ethanolic stems extract of *Solanum xanthocarpum* elicited potent anti-psoriatic activity in an Imiquimod-induced psoriatic mouse model with significant reduction of hyperkeratinisation and

expression of TNF- $\alpha$ , IL-1 $\beta$ , IL-6 and IL-17 in treated animal tissues<sup>36</sup>.

#### Antiplasmodial activity

*Solanum xanthocarpum* (Whole aerial parts) showed antiplasmodial activity (IC<sub>50</sub> Pf3D7  $\leq$  20 µg/ml) against *Plasmodium falciparum* in vitro using the SYBR Green assay. good resistance indices (0.41 - 1.4) against the chloroquine resistant INDO strain of *P. falciparum* and good selectivity indices (3 to > 22.2) were also observed against the HeLa cell line<sup>38</sup>. Volatile oils extracted by steam distillation from leaves of two plant species *Moschosma polystachyum* and *Solanum xanthocarpum* gave more than 300 minutes of (>5 hour) protection against the bite of *C. quinquefasciatus* bite without any irritation to skin<sup>37</sup>.

#### Clinical pharmacology

Since the plant is one of the important component of traditional herbal formulations such as kanakasava, in pre-clinical and clinical trials, on such formulations *S. xanthocarpum* and *S. trilobatum*, significantly improved pulmonary function parameters such as FVC, FEV<sub>1</sub>, PEFR and FEF<sub>25-75%</sub> after oral administration of whole plant powder at 300 mg. but effects were less compared to that of deriphylline or salbutamol<sup>38</sup>. In another study, both drugs improved PEFR of asthmatic individuals within 3 days of treatment with decrease in cough, breathlessness, sputum production, edema and secretions in the airways indicating bronchodilator effect. Response to the herbs was comparative to that of deriphylline but less than salbutamol. No untoward effects were reported during the study<sup>38-40</sup>.

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