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AN UPDATED OVERVIEW ON *SOLANUM XANTHOCARPUM* SCHRAD AND WENDL

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ABSTRACT

Solanum xanthocarpum Schrad and Wendl (syn.: *Solanum virginianum* L., *Solanum surettense* Burm.f.; Family: Solanaceae; English name: Yellow berried nightshade), a prickly herb is immensely important (one of the members of Dasamula of the Ayurveda) in traditional system of medicine apart from possessing various potential uses including eco-friendly attributes. An enriched information about *S. xanthocarpum* is documented which may provide a basement for its maximum exploration for human welfare.

KEYWORDS: *Solanum xanthocarpum*, updated overview.

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INTRODUCTION

Medicinal plants are wealth of mankind. India with its mega-biodiversity and knowledge of rich ancient traditional systems of medicine (Ayurveda, Siddha, Unani, Amchi and local health traditions) provide a strong base for the utilization of a large number of plants in general healthcare and alleviation of common ailments of the people[1]. *Solanum xanthocarpum* Schrad and Wendl (Family : Solanaceae; English name : Yellow berried nightshade), a prickly herb is an important plant species in Ayurveda and folklore medicine since time immemorial but there are meager reports in literature about its other potentials. Although *S. xanthocarpum* is important traditionally but lack of experimental research is a hindrance for its exploration in modern system of medicine. Efficient research can blend the traditional knowledge with modern experimental methodology for testing the efficacy and safety use of herbal drugs. An overview on *S. xanthocarpum* is presented with an objective to provide information and impetus to researchers for profitable exploration of the plant species.

Synonyms

Solanum virginianum L., *Solanum surettense* Burm. f. (source: Sharma et.al.2; www.herbalremedies.com/chest-pain.html)

Common Names

Sanskrit: Kantakari, Ksudra, Kantakarika, Dhavani, Nidigdha, Dusparsa, Agnidamani; Hindi: Kateli,Katai and Ringani; Assamese and Bengali: Kantakari; Marwari: Bhuiringani; Gujrati: Bhoyaringani; Kannad: Nelagulla; Telegu: Gurrapugatt-apu, Pinnamulaka, Nelamulaka and Vankuda; Tamil and Malayalam: Kandankattiri; Oriya: Bhejibegun and Ankranti; Punjabi: Kandyall, Chhoti mauhari and Warumba; Bihari: Rengnie, Bhat-khataya and Rangaini Janum; Manipuri: Leipungkhanga; Marathi: Dorall ringani; Nepalese: Areri.

Distribution

Reported to occur in Ceylon and Malacca through South-East Asia, Malaya, tropical Australia and Polynesia[3]. Very commonly found throughout Indian plains from seashore to hills up to 1000 m high.

Status of the plant in Ayurveda

S. xanthocarpum is one of the members of the Dasamula (ten roots) of the Ayurveda (the science of life, prevention and longevity – the oldest and most holistic medical system). It is one of the herbs from the group laghu panchamulas – five minor roots, viz. salaparni, prsniparni, brhati, kantakari and goksura. Based on prickles, in Ayurvedic text it is also known as duhsparsa – difficult to touch, bahu kanta – of many prickles, ksudrakanta – having small prickles etc. Ayurvedic texts mentioned three varieties of the species viz. violet flowered, yellow flowered and white flowered (called laksmana, which is rare).

Description

Solanum xanthocarpum is very prickly perennial herb about 1.2 m tall, usually with woody base; stem profusely branched, younger ones usually remain clothed with dense, stellate and tomentose hairs; prickles compressed straight, glabrous and shining, often 1 to 3 cm long; leaves ovate or elliptic, sinuate or subpinnatifid, obtuse or subacute, stellately hairy on both sides, armed on the midrib and often on the nerves with long yellow (colour code: FFFFCC – Web Safe Colour Chart**,** http://www.eligr.com/images/colours.gif) tipped sharp prickles; petiole long, stellately hairy and prickly; flowers are in cymes or some times reduced as solitary, bisexual, actinomorphic or only slightly zygomorphic; perianth and androecium whorls generally isomerous and usually 5- or sometimes 4- or 6-merous; calyx synsepalous, ranging from tubular to deeply cleft; calyx tube short, globose and lobes linear to lanceolate, acute, densely hairy and prickly; corolla sympetalous, ranges from forms with a short tube and rather long, reflexed lobes to forms with a long tube and short lobes; petals violet (colour code: 9999FF), lobes are deltoid, acute, and hairy outside; stamens distinct, alternating with the lobes of the corolla, and adnate to the corolla tube or perigynous zone; anther filament long, glabrous and anther opens by a pore; gynoecium consists of a single compound pistil of 2 carpels, a single style, superior ovary with 2 or rarely more locules by false partitioning, each with nearly always numerous axile ovules; ovary is ovoid and glabrous; a nectary disk generally present around the base of the ovary; fruit berry or septicidal capsule, smell sweet and attract to livestock and wild herbivores; seeds glabrous.

Chemical Constituents

Steroidal alkaloid solasodine is the principal alkaloid. Fruit contain solasonine, solasodine, solamargine, beta-solamargine, solanocarpine and solanocarpidine. Dry fruits contain traces of isochlorogenic, neochronogenic, chronogenic and caffeic acids (source: www.herbalcureindia.com/herbs/solanum). Petals yielded apigenin, stamens gave quercetin diglycoside and sitosterol. The unsaponifiable matter of fruits contains two sterols, one of which is carpesterol. Heble *et. al.*[4] isolated, crystallized and characterized chemically the diosgenin and beta-sitosterol constituents and further reported the presence of triterpenes like lupeol[5] through tissue culture technique. Tupkari *et. al.*[6] noted the presence of coumarins, scopolin, scopoletin, esculin and esculetin from plant parts of *S. xanthocarpum*; constituents were separated through column chromatography. Kusano *et. al.*[7] reported the following steroidal constituents namely, cycloartanol, cycloartenol, sitosterol, stigmasterol, campesterol, cholesterol, sitosteryl glucoside, stigmasteryl glucoside, solamargine and beta-solamargine from fruit extracts. Manye *et. al.*[8] showed that fruits have more alkaloids than other organs in the plant species and alkaloid productivity vary under different organic solvents. Hussain *et. al.*[9] in addition to alkaloid content also determined the presence of flavonoids and saponin apart from the presence of tolerable level of heavy metals like Cu, Fe, Pb, Cd and Zn. Shankar *et. al.*[10] reported and quantified bioactive steroidal glycoalkaloid – khasianine in addition to solasonine, solamargine through HPTLC.

Uses in traditional system of medicine

This herb is useful in bronchial asthma[11, 12], cough, chest pain, stopping vomiting, curing dropsy, hair fall, leprosy, itching, scabies, skin diseases amongst others. The species is also used in wound healing[13] and cardiac diseases associated with edema. Krayer and Briggs[14] reported the anti-accelerator cardiac action of solasodine and some of its derivatives. The plant possesses anti-urolithiatic and natriuretic activities[15], tumoricidal properties[16] and also anti-allergic and anti-cancerous effects[17]. Nasal administration of this herb is useful in reducing migraine and headache. The fumigation of the plant is helpful in piles. The decoction of the plant is used in the treatment of gonorrhea[2]. The plant extract possesses antipyretic, anthelmintic, carminative, stomachic, febrifuge, laxative, rejuvenating and aphrodisiac properties apart from promoting conception. Roots of this plant are used in Dashmularista, an ayurvedic tonic for lactating mothers[2] and severely used in rural areas as a successful preventive of small pox and measles. Root paste is utilized by the Mukundara tribals of Rajasthan for the treatment of hernia. Roots are also administered in flatulence and to heal constipation. Stem, flowers and fruits are prescribed for relief in burning sensation in the feet. Leaves are applied locally to relieve body or muscle pain; while its juice mixed with black pepper is advised for rheumatism[2]. Juice of berries used in sore throat whereas dried fruits are smoked in the form of cigarette to cure dental infection or toothache. Fruit extract reduces fat. Dried fruit extract of the species possesses anti-inflammatory activity[18, 17], which is due to a rare sterol- carpesterol[19]. Seeds are beneficial in irregular menstruation and dysmenorrheal.

Pharmacology

Both aqueous and alcoholic extracts of the plant possess hypotensive effect. Glycoalkaloid and fatty acid fractions of the plant extract cause liberation of histamine from chopped lung tissue. The beneficial effect of the drug on bronchial asthma may be attributed to the depletion of histamine from bronchial and lung tissue (source:

www.himalayahealthcare.com/herbfinder/h_xantho.htm). The chief alkaloid solasodine act as starting material for the manufacture of cortisone and sex hormones. Its expectorant action is due to inorganic nitrate content. Saponin constituent possesses the property of precipitating and colligating red blood cells apart from having cholesterol binding properties and bitterness[9]. Flavonoid constituent on the other hand have potent water soluble anti-oxidants properties which prevent oxidative cell damage, have strong anti-cancerous activity[9]. Bhutani *et. al.*[20] suggested that the carbohydrate moieties linked to the steroid back bones were found to strongly influence cytotoxic activity and cell death mode (apoptosis or necrossis). Lupeol, apigenin and solamargine possesses anti-cancerous property; diosgenin was found to be effective in suppressing FAS expression in cancerous cells[17]. Apigenin showd anti-allergic effect; while, diosgenin exhibited anti-inflammatory effect[17]. Lupeol also acted as multi-target agent with immense anti-inflammatory potential, targeting key molecular pathways involving nuclear factor Kappa B and other molecules[17]. Stigmasterol possesses anti-osteoarthritic properties[21].

Toxicology

There is no adverse effect was reported on use of this herb as drug.

Other potential uses

Larvicidal activity of *S. xanthocarpum* against *Aedes aegypti* (mosquito vector of dengue hemorrhagic fever), *Culex quinquefasciatus* (mosquito vector of urban bancroftian filariasis) and *Anopheles stephensi* (malaria vector) was assessed by several workers. Mohan *et. al.*[22] were of opinion that carbon-tetra-chloride extract was most effective against *A. stephensi* and *C. quinquefasciatus*. Mohan *et. al.*[23] compared the efficacy of plant extract alone and in combination with synthetic pyrethroid and cypermethrin against malaria vector and reported that cypermethrin and petroleum ether extract (1:1) combination was most efficient. Rajkumar and Jebanesan[24] reported that volatile oil (8%) extracted from leaves following steam distillation was found to possess repellent activity against filarial vector. The volatile oil did not cause any dermal irritation when applied to human skin. Bansal *et. al.*[25] evaluated larvicidal efficacy of *S. xanthocarpum* upon storage against mosquito vector in north-western Rajasthan and reported that efficacy decreased two to three times more after six months storage. Mohan *et. al.*[26] showed that pet. ether extract of the plant in combination (1:1) with synthetic insecticides (temephos and fenthion) gave best result against filarial vector. The plant species also possess molluscicidal (Asian freshwater prosobranch *Oncomelania hupensis*, freshwater pulmonate snails *Biomphalaria glabrata* and *Lymnaea stagnalis* - Wei *et. al.*[27] ; snail vector *Biomphalaria glabrata* and *Indoplanorbis exustus* - Changbunjong *et. al.*[28]) , hypoglycaemic (aqueous fruit extract on rat - Kar *et. al.*[29]), immunoprotective (water extract of fruits on mice - Sultana *et. al.*[30]), antinociceptive (tested on mice - Rahman *et. al.*[31]), antispermatozoic (oral administration of solasodine on dog - Gupta and Dixit[32]), antifertility (solasodine tested on monkey - Dixit *et. al.*[33]), antibacterial (aqueous and ether-water extract tested on *Staphylococcus aureus, Klebsiella pneumoniae, Escherichia coli* and *Bacillus subtilis* - Patel *et. al.*[34]), antifungal (fruit extract: effective against *Alternaria brassicae* - Guleriaa *et. al.*[35]; *Aspergillus niger* and *Trichoderma viride* – Singh *et. al.*[36]; *Aspergillus fumigatus*, *A. flavus* and *A. niger* - Dabur *et. al.*[37]; leaf extract : effective against *Aspergillus niger* and *A. awamori* - Patel *et. al.*[34]; against *Phoma medicaginis*, *Rhizoctonia solani* and *Alternaria brassicicola* – Fewell *et. al.*[38]), antiviral (leaf extract on TMV – Roychoudhury[39], on Reo virus – Jabbar *et. al.*[40]) and antinematodal (leaf extract effective against parasitic nematodes *Meloidogyne incognita*, *Rotylenchulus reniformis* and *Tylenchorhynchus brassicae* - Tiyagi and Ajaz[41]) properties.

Phytoremediation

Phytoremediation is an aesthetically pleasing mechanism that can reduce remedial costs, restore habitat and clean up concentration in place rather than entombing it in place or transporting the problem to another site. Carbofuran is a phenylcarbamate pesticide widely used for rice insect – *Nilaparvata lugens* but when it is sprayed about 99% of the pesticide remain residually in the environment. Teerakun *et. al.*[42] reported that *S. xanthocarpum* possesses the ability to degrade carbofuran residues in rice field soil and therefore the plant species may further be investigated for its phytoremidial role.

Chromosomal Studies

Rao[43] described $2n=24$ chromosomes in *S. xanthocarpum* from pachytene chromosome studies. Morphological data of the total length, arm ratios and the extents of differentiation of heterochromatic and euchromatic regions of each of the arms of 12 chromosomes constituting the haploid set for the species are presented. Chromosome length in the species varied from 22.4 µm to 41.2 µm and the chromosomes were median (4), submedian (6) and subterminal (2) types.

Pollen Morphology

Chaturvedi *et. al.*[44] studied pollen morphology of diploid (control), colchitetraploid and a stable androgenic

somaclonal variant of tetraploid status of *Solanum xanthocarpum* under light microscope and scanning electron microscope and found that 2*n* and colchitetraploid pollen grains are 3-zonocolporate,with granulose and scabrategranuluse exine respectively whereas the pollen grains in somaclonal variants are 3–4-zonocolporate, 2–3–4-syncolporate, 3-parasyncolporate and spiraperturate, besides a few abnormal tetrads observed in the pollen mass. It was inferred that the variability in the pollen of the somaclonal variant can either be attributed to the changes in chromosomal structure or to the changes at genetic level. Pollen viability in the species was reported as 72.22%[45].

Interspecific Hybridization

Kirti and Rao[46] studied chromosome pairing in the F_1 hybrid of *S. integrifolium* × *S. xanthocarpum* (*S. surattense*) and found regular meiosis with higher chromosome associations although the hybrids were sterile due to the formation of unbalanced gametes following pairing and exchange between partially homeologous chromosomes.

Molecular Aspects

Girija *et. al.*[47] cloned a c-DNA fragment encoding 3-hydroxy-3-methylglutaryl coenzyme A reductase (HMGR). c-DNA was synthesized by reverse transcriptase using specifically designed primers from tender leaves. Sequence comparison of HMGR from eight different plant genera revealed that solanaceous plants belonged to a single cluster. Patel *et. al.*[48] performed phytochemical investigation and molecular modeling of steroidal glycoalkaloid from *S. xanthocarpum* and 3D structure of the spironolactone and solasodine were generated and finally determined RMSD for both compounds having a low value suggesting structural and functional similarities of the mentioned compounds.

***In Vitro* Studies**

Rao and Narayanaswami[49] showed differentiation of shoots and roots can be induced when callus tissues habituated to a medium containing 2,4-D and *meso*-inositol is transferred to an auxin free medium or to a medium in which the ratio of auxin and *meso*-inositol had been altered. Heble *et. al.*[50] studied hormonal (2,4-D, IAA, IBA, kinetin and GA singly and in synergistic combinations) control of steroid synthesis in *S. xanthocarpum* in cultures and indicated chemical regulation by auxins. Saxena *et. al.*[51] reported that young leaves of *S. xanthocarpum* from axenic shoot cultures released viable protoplasts when treated with appropriate enzymes. The protoplasts on culture in modified MS medium supplemented with 2,4 -dichlorophenoxy-acetic acid (0.5 mg/l), naphthalene acetic acid (1 mg/l), kinetin (1 mg/l) and organic nutrients regenerated to form callus tissue as a result of repeated divisions. Protoplast-derived calli differentiated into shoots on MS medium enriched with kinetin (0.5 mg/l) and root was initiated by transferring the shoot-buds to basal medium. Jaggi *et. al.*[52] established static callus cultures from fruit explant of the species, determined the best condition for maximum biomass production and upon chemical analysis reported presence of β-sitosterol and lupeol. Swamy *et. al.*[53] reported somatic embryogenesis and plant regeneration from the cotyledon and leaf explant of *S. xanthocarpum*. Maximum percentage (71.2%) of somatic embryo germination and plantlet formation was found at 0.5 mg/l IAA+2.0 mg/l BAP, but they did not germinate on ½ MSO and MSO media. The post transplantation survival rate of plants was 65-70%. Borgato *et. al.*[54] reported plant regeneration from leaf protoplasts and the regenerated plants were of normal morphology.

CONCLUSION

Keeping in mind that herbal medicines are gaining growing interest because of their cost effective and eco-friendly attributes, this is an urgent need to meet the ever growing demand of medicinal plants in the market and it will pose a challenge for researchers, farmers, conservationist and policy makers to manage and use our natural resources wisely. The updated overview on *S. xanthocarpum* is in light of it.

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