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A BRIEF REVIEW ON *SOLANUM XANTHOCARPUM* ALONG WITH THE EVALUATION OF ANTICANCER POTENTIAL IN CARPESTEROL

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ABSTRACT: The "deadly nightshade" family, commonly known as "black nightshades," it's also used as a traditional medicine system in a country like India and China. *Solanum xanthocarpum* is known to contain alkaloids, steroids, glycol-alkaloids, steroid saponins, glycoproteins, that exhibit antitumor activity. This review explores the phytopharma-cological properties of *Solanum xanthocarpum* and summarizes its wide range of pharmacological applications to understand and integrate potential image issues as multipurpose medicines. Solanocarpidine and a phytosterol known as Carpesterol are also present. The seed oil contains Carpesterol. Diosgenin, lanosterol, sitosterol. Solasonnine, solamargine, and solasodine have been isolated from the plant. The roots and fruits are used for medicinal purposes. The herb is useful both internally as well as externally. The apoptotic effects and the amount of DNA fragmentation increased in a dose-dependent manner after the treatment with the protein. Authors believe this glycoprotein is a natural anticancer agent due to its potential to induce apoptosis in the HTC29 cell.

INTRODUCTION: Herbal medicines are being used by about 80% of the world population, primarily in developing countries, for primary health care. They have stood the test for their safety, efficacy, cultural acceptability, and lesser side effects. The plant *Solanum xanthocarpum* Linn. (Solanaceae) is commonly called black nightshade in English, Makoi in Hindi, Kachchipandu in Telugu, Munatakali in Tamil, Piludi in Gujarati & Kamuni in Marathi. *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.

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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). It is an erect, divaricately branched, unarmed, suffrutescent annual herb. Leaves ovate or oblong, sinuate-toothed or lobed, glabrous; flowers 3-8 in extra-axillary drooping subumbellate cymes; fruits purplish-black or reddish berries; seeds many, discoid, yellow, minutely.

Various Therapeutic Activities of *S. Xanthocarpum* Linn:

TABLE 1: *SOLANUM XANTHOCARPUM* THERA-PEUTIC USES

Anti-seizure	Antithrombiotic	Antifungal
Anti-poison	Immunostimulant	Cardioprotective
Anti-inflammatory	Antipsoroiatic	Hypoglycemic
Anti- pyretic	Ostreoarthritic	Neuroprotective
Antiproliferative	Anticancer	Hemolytic
Anti-haemorroidal	Antimicrobial	Spasmolytic
Antioxidant	Larvicidal	Antiviral
Hepato protective	Snail killer	Antifertility
Wound healer	Antioxidant	Antiasthamatic
Nephrorotective	Antiurolithiatic	Antidiarrhoeal

(A) SHRUB (B) LEAVES (C) ROOTS (D) FLOWERS

FIG. 1: VARIOUS PARTS OF *SOLANUM XANTHOCARPUM*- VARIOUS PARTS ARE SHOWN BELOW

TABLE 2: TAXONOMIC CLASSIFICATION

Kingdom	Plantae
Sub-kingdom	Tracheobionta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Asteridae
Order	Solanales
Family	Solanaceae
Genus	Solanum

TABLE 3: 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,
Kannad	Nelagulle

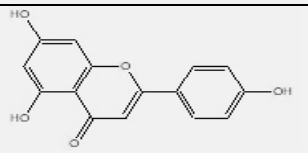
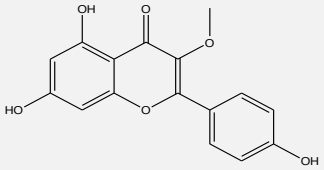
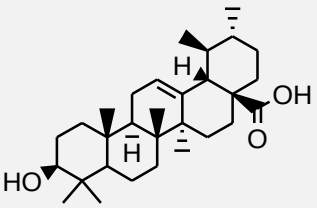
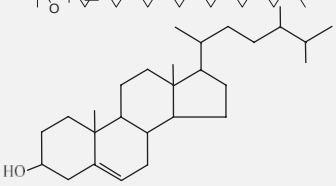
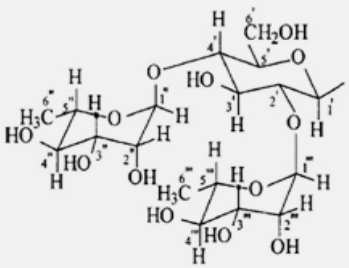
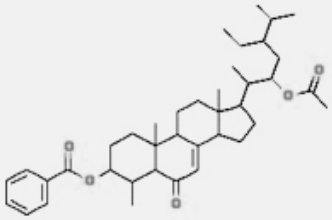
Black nightshade is a plant, an annual weed that grows up to 60cm tall, is branched, and usually straight, growing wild in wastelands and crop fields. Alternate leaves are deep ovate green with an indented margin and acuminate at the tip. The flowers are white with a yellow-colored center. The berries are green early and turn orange or black when ripened.

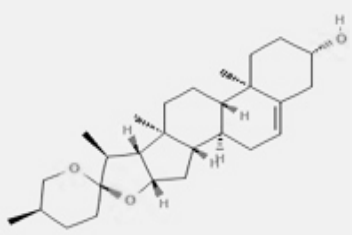
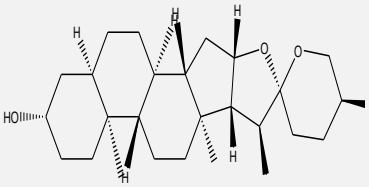
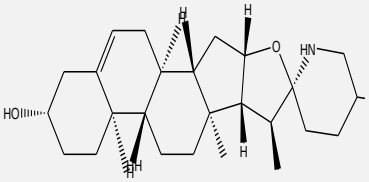
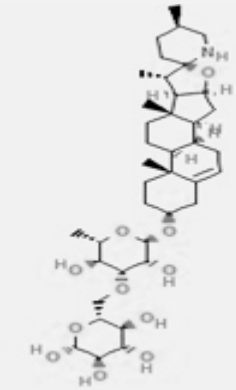
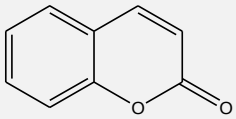
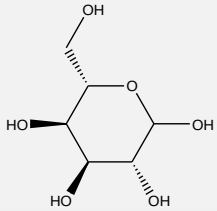
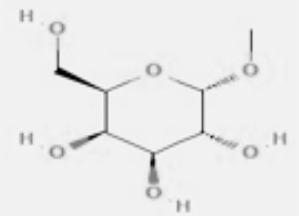
Phytochemistry: It leads to the isolation of glycoalkaloids, solasonine Solanacarpine, Solanocarpidine, Carpesterol. From the non-alkaloidal portion, a glycoside of β- sitosterol with galactose as a sugar moiety has been obtained along with two phenolic substances, which could be identified as methyl caffeate and caffeic acid.

The fruits are reported to contain several steroidal alkaloids like solanacarpine and Solamargine. Other constituents like caffeic acid coumarins like aesculetin and aesculin, steroids Carpesterol, diosgenin, campesterol, daucosterol, and triterpenes like cycloartenol and cycloartenol were reported from the fruits. Steroidal glycoalkaloids are naturally occurring secondary plant metabolites that are formed in several foods, including

potatoes, tomatoes, and eggplants. Although they are reported to be potentially noxious, glycoalkaloids and hydrolysis yield without the carbohydrate side chain (aglycons) also have beneficial effects. Carpesterol acetate is obtained from the plant of the *Solanaceae* family [1]. The chemical constituents present in them are a part of the physiological functions of living flora; hence, they are believed to have better compatibility with the human body [2, 3]. This plant also has Lupeol, Oleanolic acid, Ursolic acid, β-Sitosterol, Campesterol, Ergosterol, Withanolide, Apigenin, Quercetin, and many more other chemical constituents as shown in **Tables 4** & **5** [4, 5, 6, 7, 8, 9, 10].

TABLE 4: VARIOUS CHEMICAL CONSTITUENTS PRESENT IN *SOLANUM XANTHOCARPUM*

S. no.	Name of chemical compound	IUPAC NAME	Structure	Part used	References
1	Apigenin	5,7-dihydroxy-2-(4-hydroxyphenyl)chromen-4-one		DL, RT ,FT	(4)
2	Flavone -3-Methoxyapigenin	5-hydroxy-7-methoxy-2-(4-methoxyphenyl)chromen-4-one		FT	(5)
3	Ursolic acid	.(1S,2R,4aS,6aR,6aS,6bR,8aR,10S,12aR,14bS)-10-hydroxy-1,2,6a,6b,9,9,12a-heptamethyl-2,3,4,5,6,6a,7,8,8a,10,11,12,13,14b-tetradecahydro-1H-picene-4a-carboxylic acid		RT	(6)
4	Phytol acetate	(E)-3,7,11,15-tetramethylhexadec-2-enyl] acetate		PNS	(7)
5	Campesterol	l(3S,8S,9S,10R,13R,14S,17R)-17-[(2R,5R)-5,6-dimethylheptan-2-yl]-10,13-dimethyl-2,3,4,7,8,9,11,12,14,15,16,17-dodecahydro-1H-cyclopenta[a]phenanthren-3-ol		FT	(8)
6	Beta solmergine	2S,3R,4R,5R,6S)-2-[(2R,3S,4S,5R,6R)-4-hydroxy-2-(hydroxymethyl)-6-[(1S,2S,4S,5'R,6R,7S,8R,9S,12S,13R,16S)-5',7,9,13-tetramethylspiro[5-oxapentacyclo[10.8.0.02,9.04,8.013,18]icos-18-ene-6,2'-piperidine]-16-yl]oxy-5-[(2S,3R,4R,5R,6S)-3,4,5-trihydroxy-6-methyloxan-2-yl]oxyoxan-3-yl]oxy-6-methyloxane-3,4,5-triol		FT	(9)
7	Nor-carpesterol	(3S,4S,5S,9R,10R,13R,14R,17R)-17-[(2S,3R,5R)-5-ethyl-3-hydroxy-6-methylheptan-2-yl]-4,10,13-trimethyl-6-oxo-1,2,3,4,5,9,11,12,14,15,16,17-dodecahydrocyclopenta[a]phenanthren-3-yl] benzoate		P.N.S.	(4)

8	Diosgenin	1S,2S,4S,5'R,6R,7S,8R,9S,12S,13R,16S)-5',7,9,13-tetramethylspiro[5-oxapentacyclo[10.8.0.02,9.04,8.013,18]icos-18-ene-6,2'-oxane]-16-ol		TC	(4)
9	sarsapogenin	(1R,2S,4S,5'S,6R,7S,8R,9S,12S,13S,16S,18R)-5',7,9,13-tetramethylspiro[5-oxapentacyclo[10.8.0.02,9.04,8.013,18]icosane-6,2'-oxane]-16-ol		PNS	(8)
10	Tomatidinol	(1S,2S,4S,6S,7S,8R,9S,12S,13R,16S)-5',7,9,13-Tetramethylspiro[5-Oxapentacyclo[10.8.0.02,9.04,8.013,18]Icos-18-Ene-6,2'-Piperidine]-16-Ol		FT	(4)
11	Solasurine	(2R,3R,4S,5S,6R)-6-[[(2S,3S,4R,5R,6R)-3,5-Dihydroxy-2-Methyl-6-[(1S,2S,4S,5'R,6R,7S,8R,9S,12S,13R,16S)-5',7,9,13-Tetramethylspiro[5-Oxapentacyclo[10.8.0.02,9.04,8.013,18]Icos-18-Ene-6,2'-Piperidine]-16-Yl]Oxyoxan-4-Yl]Oxymethyl]Oxane-2,3,4,5-Tetrol; (3beta,22alpha,25R)-Spirosol-5-En-3-Yl 6-Deoxy-O-Beta-D-Glucopyranosyl-Alpha-L-Mannopyranoside		BR	
12	Coumerin	2H-1-benzopyran-2-one		DL,RT, FT	
13	L-altrose	(3R,4S,5R,6S)-6-(hydroxymethyl)oxane-2,3,4,5-tetrol		P.NS.	(8)
14	Lycopene	(6E,8E,10E,12E,14E,16E,18E,20E,22E,24E,26E)-2,6,10,14,19,23,27,31-octamethyldotriaconta-2,6,8,10,12,14,16,18,20,22,24,26,30-tridecaene		FT	(2)
15	Tetracosane	Tetracosane		PNS	(10)

Here, DL- Dried leaf, RT-Root, FT-Fruits, TC-Tissue culture, BR-Bark, ST-Stem, PNS- Part not specified.

TABLE 5: PHYTOCHEMICAL SCREENING OF DIFFERENT PARTS OF *SOLANUM XANTHOCARPUM* [10]

S. no.	Phytochemical constituents	Plant parts	Aqueous extract	Methanol extract	Ethanol extract	Petroleum Ether extract	Ethyl Acetate extract	Diethyl Ether extract	Chloroform extract
1	Flavanoids	Stem	_	+	+	_	_	_	_
		Leaves	_	_	_	+	_	_	+
		Fruits	_	+	+	+	_	_	+
		Roots	_	_	-	-	-	-	-
2	Terpenoids	Stem	-_	+	+	_	+	+	+
		Leaves	_	+	+	_	+	+	+
		Fruits	_	+	+	+	+	+	+
		Roots	_	+	+	+	+	+	+
3	Steroids	Stem	_	_	+	_	+	_	+
		Leaves	+	+	+	+	+	+	+
		Fruits	_	+	+	+	+	+	+
		Roots	_	+	+	+	+	+	+
4	Saponins	Stem	_	_	_	_	_	_	_
		Leaves	+	+	+	_	_	_	_
		Fruits	+	+	_	_	_	_	_
		Roots	_	_	_	_	_	-	_
5	Tannins	Stem	_	_	_	_	_	_	_
		Leaves	_	_	_	_	_	_	-
		Fruits	_	-	_	-	-	-	_
		Roots	_	-	-	_	-	-	-
6	Alkaloids	Stem	+	+	+	_	_	_	_
		Leaves	+	+	+	_	_	_	_
		Fruits	+	+	+	_	-	-	_
		Roots	+	+	+	_	_	_	_
7	Cardiac glycosides	Stem	_	_	+	+	+	+	_
		Leaves	+	+	+	_	+	+	_
		Fruits	_	+	+	+	_	+	+
		Roots	_	+	+	+	_	+	_
8	Phenols	Stem	_	+	+	_	+	_	_
		Leaves	_	+	+	_	+	_	_
		Fruits	_	+	+	_	+	_	_
		Roots	_	+	+	_	+	_	_

The current status of the health care system in the adequacies of synthetic drugs is likely to be more glaring in the coming years. It has been reported that an alarming increase in the number of diseases and disorders caused by synthetic drugs prompts a switch to traditional herbal medicines.

India has over 1, 08,276 species of bacteria, fungi, animals, and plants already identified and described. Out of these about84% species constitutes fungi (21.2%), flowering plants (13.9%) and insects (49.3%). Natural products, including plants, animals, and minerals, have been the basis of treating human diseases. The current accepted modern medicine or allopathy has gradually developed over the years through scientific and observational efforts of scientists. However, the basis of its development remains rooted in traditional medicine and therapies. The selection of a 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 developing new drugs from plants.

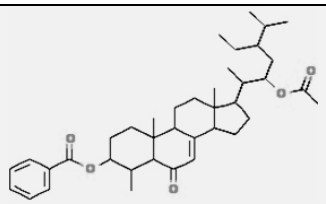
Ancient literature also mentions herbal medicines for age-related diseases such as memory loss, osteoporosis, diabetic wounds, immune and liver disorders, etc., for which no modern medicine or palliative therapy is available [11, 12, 13].

TABLE 6: ETHNOBOTANICAL USAGE EVIDENCE

S. no.	Disorders	Part/methods	Folk area	References
1	Hernia	Root-paste	Mukundara tribals of Rajasthan	(14)
2	Anthelmintic, Anti-inflammatory, Bronchitis, Colds, Cough, Diuretic, Dysentery, Febrifuge, Fevers, Haematuria, Leprosy, Piles, Sedative, Tooth pain, Ulcers	Seeds/ Roots /Leaves/Barks	Taindol village, district Jhansi, Uttar Pradesh	(15)
3	A svege table and local healers	Fruits	Manipur	(4)
4	Diabetes	Decoction of the fruit	Traditional healers of Jharkhand and Orissa	(4)
5	Diabetes	Hot aqueous extract of the matured fruits	Kondh tribes of Dhenkanal district of Orissa	(16)
6	Piles	Root poultice	Villages of South India	(17)
7	Cancer	Whole plant	Tribal practitioners in South Gujarat	(18)
8	Remedy for cough and asthma	Seeds	Not specified	(19)

Carpesterol: Carpesterol was the first compound isolated from the lipid fraction of plants; more than three decades ago, no structural studies of the sterol have been reported. Because it was hoped that a structural knowledge of carp sterol 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 [16].

TABLE 7: CHEMISTRY, PHARMACOLOGY AND BIOGENESIS:

Structure of Carpesterol	
Molecular Formula	$C_{39}H_{56}O_5$
English name	Carpesterol acetate
IUPAC Name	17-(3-acetyloxy-5-ethyl-6-methylheptan-2- yl)-4,10,13-trimethyl-6-oxo-1,2,3,4,5,9,11,12,14,15,16,17-dodecahydrocyclopenta [a] phenanthren-3-yl] benzoate
Molecular Weight	604.859 g/mol
Rf value	0.462
Mass	604.859 g/mol
IR Data	The sharp peak at 1062, 1240 cm-1 indicated the presence of C-O-C (ether)
UV range	The isolated compound solasodine in Methanol showed an absorbance peak at 212 nm

Uses of Carpesterol: The juice of the plant or an ointment prepared from it is externally applied to cure certain skin problems and tumors. A decoction of black nightshade's stalk, leaves, and roots is beneficial for wounds and cancerous sores. Freshly prepared plant extract is effective in treating liver cirrhosis and works as an antidote for opium poisoning [20, 21, 22, 23, 24].

General Methods of Isolation of Phytoconstituents and Evaluation of Biological Activities:

Selection of Plant (Part) & Authentication of Plant:

- Material Isolation of compounds using a suitable extracting solvent
- Column chromatography of the extract
- FTIR spectra measured different isolated compounds
- Structure Elucidation of each isolated compound using FTIR, Mass Spectra,1H, and 13C NMR, HPLC
- UV Screening for biological activities
- Structure of compound Efficacy against various cell lines

- ❖ Calculation PK/PD parameters
- ❖ Establishment of isolated compound bioefficacy concerning standard compound for the same activity.

Isolation Techniques of "Carpesterol" from *Solanum xanthocarpum* Family Solanaceae:

- ➢ Selection of plants belonging family Solanaceae
- ➢ Authentication of plant
- ➢ Carpesterol was the first compound isolated from the lipid fraction of plant
- ➢ Shade dried fruits were extracted with hot 80% ethanol/ methanol under reflux.
- ➢ The ethanol/ methanol concentrate was repeatedly shaken with benzene, ether, and ethyl acetate.
- ➢ The benzene soluble portion on elaborate column chromatography over neutral alumina yielded in benzene: pet. Ether (3:1) elutes.
- ➢ A pure compound (0.05% yield) having M.P. 245-247 °C

Evaluation of New Biological Activity of Carpesterol: The study was aimed at evaluating the anticancer activity of the fruits of *Solanum xanthocarpum* on the *HeLa* cell line. The fruits of *Solanum xanthocarpum* methanolic extract were tested for their inhibitory effect on *HeLa* Cell Line. The cell line's percentage viability was carried out using Trypan blue dye exclusion method. The cytotoxicity of *Solanum xanthocarpum* on *HeLa* cells was evaluated by the SRB assay and MTT assay. *Solanum zanthocarpum* methanolic extract has a significant cytotoxicity effect on *HeLa* Cell Line in the concentration range between 10 mg/ml to 0.0196 mg/ml by using SRB assay, and the study also showed that inhibitory action on *HeLa* cell line in the concentration range between 10 mg/ml to 0.0196 mg/ml by using MTT assay. IC_{50} value and R2 value of *Solanum xanthocarpum* on *HeLa* cell and *Vero* cell were 847.8 and 0.8724, 908.8 and 0.1017, respectively, by SRB assay. IC_{50} value and R^2 value of *Solanum xanthocarpum* on *HeLa* cell were 265.0 and 0.9496 respectively by MTT assay. The IC_{50} value of *Solanum xanthocarpum* on the *Vero* cell was 6.862 by MTT assay. The R^2 value of *Solanum xanthocarpum* was not found by MTT assay. From the performed assay, methanolic extract of these drugs shows greater activity on the *HeLa* cell line and little activity on the *Vero* cell line. That means *Solanum Xanthocarpum* can be used as anticancer activity). Plants have served as an important source of potent anticancer drugs for decades. The search for anti-cancer drugs from plant sources started in the 1950s, with the discovery of the vinca alkaloids (vinblastine and vincristine) and podophyllotoxin. This search spanned four decades until the 1990s, when taxanes and camptothecins were launched as anti-cancer drugs.

Plant-based molecules' success still inspires researchers to search for newer anticancer agents from plants. Steroidal compounds are an important class of secondary metabolites, which have been reported to exhibit a wide range of pharmacological properties that include hypocholesterolemic, antioxidant and antidiabetic, *etc*. However, of particular interest is the apoptosis-inducing activity of steroidal compounds. Amongst the steroidal class of compounds, diosgenin has been previously reported to induce apoptosis in different human cancer cell lines. Thus, to identify effective apoptosis-inducing agents, we have tested several steroidal compounds structurally related to diosgenin (including diosgenin) isolated from two Indian medicinal plants, Solan *xanthocarpum.*

Effects of Herbal Drugs on Human Health: Herbal Medicines are readily available in the market from health food stores without prescriptions and are widely used in India, China, the USA, and all over the globe. According to a recent survey, most people who use herbal medicines do not inform their physicians about their consumption which can cause abnormal test results and confusion in proper diagnosis.

Drug herb interactions can result in the unexpected concentration of the therapeutic drug. Several herbal products interfere with immunoassays used to monitor therapeutic drug concentrations. Herbal medicines can also cause undesired effects. Therefore, the common belief that anything natural is safe is not correct.

The US food and drug administration mandates that only medicine has to be proven safe before being released into the market. Herbal products do not fall under the category of drugs as long as they are not marketed for the prevention of any diseases, their use is much more because of their easy accessibility, no expert consultation required, are considered safe to use and also because primary health in qualitative and quantitative terms. We should make all these easily marketed Ayurvedic and other herbal medicines FDA approved and increase public awareness about the pros and cons of their uses. The common belief that anything natural is safe is not correct. In the United Kingdom, any product that is not granted a license as a medical product by Medicine Control Agency is treated as food, and no health claim or medical advice can be given on the label.

Labeling of herbal products may not reflect the content, and adverse events or interactions attributed to a specific herb may be related to misidentification of the plant. Many commonly used herbal medicine in their irregular, high doses or with other medications in the long term is toxic. Toxic effects of herbal medicines range from allergic reactions to cardiovascular, hepatic, renal, neurological, and dermatologic toxic effects. The manufacturers of these products are not required to submit proof of safety and efficacy to the U.S. Food and Drug Administration before marketing. For this reason, the adverse effects and drug interactions associated with herbal remedies are largely unknown. Ginkgo-biloba extract, advertised as improving cognitive functioning, has been reported to cause spontaneous bleeding, and it may interact with anticoagulants and antiplatelet agents. The herb is useful both internally as well as externally. Natural sources such as Indian medicinal plants and herbal drugs require special attention. Antioxidants neutralize toxic and volatile free radicals. Humans get exposed to adverse physiochemical, environmental, or pathological agents; this delicately maintained balance is shifted in favor of pro-oxidants resulting in oxidative stress.

CONCLUSION: Carpesterol, a novel Phytosterol obtained from different plants of the family *Solanaceae* possesses several pharmacological activities not previously found within the group have been discovered. The most notable of these new properties are anti-inflammatory, anti-hyperlipidemic activity, digitalis-like activity, coronary dilatory activity, and central nervous system activity. At the same time, some new biological activities are also being mentioned i.e. with androgenic, estrogenic, progestational and anti-tumor activity. In recent advantages related to anticancer drug research, it is a fact that cox-1/cox-2 has a significant role in apoptosis. Cox-2 inhibition of leukotrienes on human erythroleukemia (HEL) and human acute monocytic leukemia (Mono Mac 6) cell lines indicated that the compound having cox-2 inhibition could be co-related in anti-cancer activity. Carpesterol, by its structure (basic steroidal nucleus) possesses all the activities mentioned under steroids. The over-attachment group further contributes to anti-fertility; cancer of the human reproductive system, and HIV-mediated cancers like other Phytosterol, *e.g*., β-sitosterol is also Phytosterol. It's also rivals the new research on how the different phytochemicals of *S. xanthocarpum*are active in the biological system. There is also a wide space for researchers to evaluate the more incredible potential of this miraculous plant.

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