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GENUS *HYDNOCARPUS*: A REVIEW

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ABSTRACT

There are around40species in the genus *Hydnocarpus* whichare indigenous to Asia's tropical rain forests,ranging from India and Sri Lanka in the west to Philippines and Indonesia in the east. Many species in *Hydnocarpus* and its related genera in the family Flacourtiaceae were tried in the treatment of Hansen's disease (HD). The most important sources were kalauw (*Hydnocarpus kurzii*) in Burma, thuvaraka (*Hydnocarpus pentandra*) in south eastern India and tai-fung-isze (*Hydnocarpus anthelmintica*) in China. Only *Hydnocarpus pentandra* grew abundantly and accessibly in nature; therefore its oil was used extensively. However the original chaulmoogra, *Hydnoarpus kurzzi* was widely cultivated for its therapeutic oil. In the late nineteenth century, the western physicians began using it in oral, topical and parental forms to treat Hansen's disease (HD). This review article explains the genus *Hydnocarpus*.

Key words: *Hydnocarpus*, Hansen's disease, Flacourtiaceae, Chaulmoogric acid, Hydnocarpic acid, Hydnocarpin.

INTRODUCTION

Medicinal plants based traditional systems of medicines are playing important role in providing health care to large section of population (Ravishankar B and Shukla VJ, 2007). Population rise, inadequate supply of drugs, prohibitive cost of treatments, side effects of several allopathic drugs and development of resistance to currently used drugs for infectious diseases have led to increased emphasis on the use of plant materials as a source of medicines for a wide variety of human ailments. Herbal medicines are in great demand in the developed world for primary health care because of their efficacy, safety and lesser side effects. They also offer therapeutics for age-related disorders like memory loss, osteoporosis, immune disorders, etc. for which no modern medicine is available. Global estimates indicate that 80% of about 4 billion population cannot afford the products of the Western Pharmaceutical Industry and have to rely upon the use of traditional medicines which are mainly derived from plant material. This fact is well documented in the inventory of medicinal plants, listing over 20,000 species.

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In spite of the overwhelming influences and our dependence on modern medicine and tremendous advances in synthetic drugs, a large segment of the world population still likes drugs from plants. In many of the developing countries the use of plant drugs is increasing because modern life saving drugs are beyond the reach of three quarters of the third world's population although many such countries spend 40-50% of their total wealth on drugs and health care. As a part of the strategy to reduce the financial burden on developing countries, it is obvious that an increased use of plant drugs will be followed in the future (Joy PP *et al.*, 1998)

Hydnocarpus (hydno=truffle and carpus=fruit) is a genus in the major group *Angiosperms* (Flowering plants),of medium to large trees grows upto 15-20 m tall and has large shiny green lanceolate alternate leaves, small *Dioceous recemose* flowers, and capsular fruits with brittle, velvet-textured shells. Inside are many large, hard, angular seeds embedded in a cream-colored pulp. Which are several sources of chaulmoogra oil and hydnocarpus oil.

There are around 40species in the genus *Hydnocarpus* are indigenous to Asia's tropical rain forests, ranging from India and Sri Lanka in the west to Philippines and Indonesia in the east. The genus is well

known for its use in the treatment for leprosy. Seeds yield Hydnocarpus or chaulmoogra oil that is used in leprosy. Seed oil is anti-inflammatory, alterative, tonic, used as local application in rheumatism, sprains, braises sciatica and chest affections. Seed and seed oil are also used in leucoderma, worm infection, polyuria, pruritus, eye diseases and sinus wounds.

***Hydnocarpus alpine* Wight**

Botanical Description

Trees are up to 8 m tall. Trunk and bark dark grey, slightly rough; blaze light orange (figure1c).Branches and branchlets subterete, glabrous, drooping. Leaves(figure1a) simple, alternate, distichous; petiole 0.7-1.6 cm long, swollen at both ends, canaliculate, glabrous; lamina 9-26 x 2.5-8.5 cm, usually lanceolate, apex gradually acuminate or subacute, base rounded or acute, sometimes sub attenuate, margin entire, coriaceous, glabrous; midrib raised above; secondary nerves 6-11 pairs, ascending towards apex; tertiary nerves reticulo-percurrent. Flowers unisexual, solitary or in short fascicles, white. Fruits and seeds (figure1b) are berry, globose, to 6.5 cm across, brown tomentose, pericarp woody; seeds numerous. Flowering and fruiting: February–July. Located in India, Indonesia, Malaysia and Sri Lanka.

Chemical constituents

Chaulmoogric acid, hydnocarpic acid, apigenin, hydnocarpin, fixed oils, tannins.

Medicinal properties

Seeds are medicinally used for leprosy, arthritis, ascaris, rheumatism and tap worm diseases. Wood is used as fuel and for agricultural implements. An investigation has been conducted on isolation and structural characterization of 2R,3R taxifolin 3-o-rhamnoside from ethyl acetate extract off *Hydnocarpus alpine* and its hypoglycemic effect by attenuating hepatic key enzymes of glucose metabolism in streptomycin – induced diabetic rats. The results obtained where compared with glibenclamide a standard hypoglycemic drug. The results suggested that the rhamnoside from *Hydnocarpus alpina* could be used as a therapeautic agent to treat diabetes mellitus (Balamurugan R *et al.,* 2015). A study has been conducted to synthesize and characterize silver nanoparticles from leaf extract of *Hydnocarpous alpine* and studied on its application as a potent antimicrobial and antioxidant agent. They reported that the FT-IR analysis showed the presence of C-O, -C-N , -C=C- , N-H , O-H and C-H functional groups and the antimicrobial activity and *invitro* antioxidant activity was evaluated (Kandakumar S *et al.,* 2014). A study has been performed on evaluation of phytochemical constituents of Indian medical plant *Hydnocarpus alpine* Wight. In this study the leaves shows the presence of alkaloids, tannins, flavonoids and coumarins. In this study revealed that the plant has anti-larvicidal, anti-feedant,anti-microbial activities (Dhanasekaran M *et al.,* 2013). A study has been conducted on bio efficacy of neem oil formulation with *Hydnocarpus alpine* leaf extract against spodoptera litura. They reported that the ethyl acetate extract of *Hydnocarpusalpine* showed maximum antifeedant and larvicidal activity at 5% concentration. They further subjected the ethyl acetate extract to fractionation using hexane, ethyl acetate,acetone & methanol by column chromatography and thin layer chromatography. They reported that 8th fraction showed maximum antifeedant and insecticidal activity (Vendan E *et al.,* 2013)

***Hydnocarpus kurzzi* (King) Warb. (*H. heterophyllus*)**

Botanical Description

A medium-sized evergreen tree, 12-15 m high. Leaves (figure2a)thinly coriaceous, entire, 18-25 cm long, lanceolate or oblong-lanceolate. Flowers in auxiliary cymes; petals 8, in 2-rows, broadly ovate, ciliate. Fruit, size of an orange, tawny-velvety. Plant is distributed in forests of Chittagong, Chittagong Hill Tracts, Cox's Bazaar and Moulavi Bazaar.

Chemical Constituents

Seeds yield a fixed oil, called chaulmoogra oil, which contains glycerides of cyclopentenyl fatty acids like hydnocarpic acid (48%), chaulmoogric acid (27%), gorlic acid (23%), oleic acid (12%) and palmitic acid (6%). Bark contains a large amount of tannins.

Medicinal properties

Seeds yield chaulmoogra oil, which is used in leprosy and other skin diseases. In China and Argentina the oil is used against cancer. Fruits are fish poison. The bark of the tree is said to be used as a febrifuge. A study has been conducted on oral tolerance and preliminary phytochemical and toxicity studies on *Hydnocarpus kurzii* bark methanolic extract. They found out that the extract significantly and dose dependently reduced blood glucose loaded mice and the result obtained is compared with standard drug glibenclamide. They have reported that methanol extract of the bark can be used with safety to improve glucose tolerance in glucose impaired cases (Levy L, 1983). A study has been performed on the seeds *of Hydnocarpus kurzii* contain 30% oil, of which the three principal fatty acids are hydnocarpic, chaulmoogric, and gorlic acids. The oil also contains lower amounts of homologs, including myristic, palmitic, stearic, palmitoleic, oleic, linoleic and linolenic acids (Erena islam *et al.,* 2015).An investigation has been conducted on the fatty acid composition of the seed oils of the species, *Hydnocarpus kurzii*, *Hydnocarpus wightiana* and *Hydnocarpus odorata* by gas-liquid chromatographic

(GLC) analysis. The individual fatty acids were found to be: hydnocarpic, chaulmoogric, gorlic, myristic, oleic, linoleic, linolenic respectively (Sengupta A *et al.,* 1973).

***Hydnocarpus anthelminticus* Pierre ex Laness**

Botanical Description

These evergreen trees are relatively tall, often reaching 30m in height in dense jungles. Less often they grow as shrubs, if provided with less favorable climate and soil conditions. The upright straight trunk is covered by a gray-brown bark. *Hydnocarpus anthelminticus* leaves (figure3c) are oblong or lanceolate and have a somehow leathery texture on both sides. They are green when fresh and turn into a reddish-brown shade while drying. *Hydnocarpus anthelminticus* blooms in inflorescences of 2 or 3 flowers (figure3a), having a distinctively pleasant fragrance and a yellowish or pinkish shade. They result into round, woody berries(figure3b) measuring between 8 and 12 cm in diameter, colored in orange-brown when fresh and dark brown with white dots when dried. Each such berry encloses 30 to 50 large seeds which contain fatty oil with characteristic odor and acrid taste held in high esteem by herbalists around the world. The extracted essential oil is either a brownish-yellow liquid or soft solid. Located in east India, Burma, Thailand, Indochina.

Chemical constituents

It contains mixture of glycerids. Fatty acids like hydnocarpic acid, chaulmoogric acid, gorlic acid, oleic and palmitic acid.

Medicinal properties

The chemical structure of ***Hydnocarpus anthelminticus*** is a complex puzzle of active ingredients, of which the one with the highest level of antimicrobial activity is the hydnocarpic acid, an alipophilic compound. The essential oil extracted from the seeds of this tree has been widely used intravenously or intramuscularly against leprosy. Not only that it has strong antimicrobial and antibacterial activity, but it also acts as an astringent agent, being helpful in cases of acne and excessive sebum production. It also enhances skin cells hydration and has a tonic, smoothening effect upon them. Products obtained from dried and powdered seeds are used against a variety of skin conditions, ranging from superficial wounds to cuts, burns and ulcerations. A study has been performed on pharmacogonostic study of *Hydnocarpus anthelminticus* seeds endemic to Thailand. Microscopic investigation revealed numbers of aleuronegrains, sclereid of seed coat and oil droplets. The mean contents of foreign matter, total ash, acid insoluble ash, moisture, ethanol soluble extractive, water soluble extractive and loss on drying were 0.04,1.61,0.29,8.83,23.93,3.95 and 7.38% respectively (Bunrathep S *et al.,* 2014). An investigation has been conducted on the nutrient and mineral content of six different samples of *hydnocarpus anthelminticus* cultivated in Thailand. From the results they revealed that *Hydnocarpus anthelminticus* pulps indigenous to different agro-climatic regions of Thailand contained an appreciable amount of nutrients and might be used as a good supplement for some nutrients **(**Jongrungruangchok S *et al.,* 2013)

A work has been conducted on different extractions using n-hexane, ethyl acetate or n-butanol of seeds of *Hydnocarpus anthelminthicus*, have been evaluated for wound healing activity using an *in-vitro* acute inflammation model and an *in-vivo* diabetic ulcer model. Of these extracts, the butanol extract showed the most potent activity at a dose of 2 mg/kg in diabetic mice with ulcers. These results suggest that the extract may be a novel therapeutic candidate for the treatment of diabetic ulcers (Lee GS *et al.,* 2010; Lee GS *et al.,* 2012a). A study has been performed on the ethyl acetate fractionof *Hydnocarpus anthelminthicus* induces inflammation *in-vitro*, and it is proposed that the constituents chaulmoogric, hydnocarpic, and gorlic acids may not underlie this activity (Lee GS *et al.,* 2012b).An investigation has been performed on anti inflammatory flavonolignans of*Hydnocarpus anthelmintica* seeds. A new flavonolignan, anthelminticaol A(1), together with four known compounds,was isolated from the EtOAc extracts of the seeds of *Hydnocarpus anthelmintica*. Their structures were elucidated using extensive spectroscopic techniques (Wang JF *et al.,* 2011). A study has been conducted on *Hydnocarpus anthelminthicus* and several compounds have been isolated from seeds of *Hydnocarpus anthelmintica* including p-hydroxybenzaldehyde, 4-hydroxy-3-methoxy benzaldehyde, 5-hydroxyindole-3-ald ehyde, ω-hydro-xypropioguaiacone, evofolin-B, daucosterol, oleanolic acid, chrysoeriol, 5,40-dihydroxy-7-methoxyflavone and luteolin (Junfeng W *et al.,* 2011)**.** A study has been performed on antituberculosis agent and an inhibitor of the para-aminobenzoic acid biosynthetic pathway from *Hydnocarpus anthelmintic* seeds. In the study investigation on the extracts of*Hydnocarpus anthelmintic* seeds led to isolation of three new compounds, anthelminticans A-C(1-3,res,) and the two known ones, namely chalmoogric acid (4) and ethyl chalmoograte(5). Biological assays revealed that the compounds 1-5 significantly inhibit mycobacterium tuberculosis (MTB) growth with MIC values 5.54,16.70,4.38,9.82 and 16.80 µM respectively (Wang JF *et al.,* 2010). A work has been conducted on cytotoxic mycoepoxydiene derivatives from an entophytic fungus *Phomopsis* sp.Isolated from *Hydnocarpus anthelminticus*. They reported that deacetylmycoepoxydiene and mycoepoxydiene exhibit potent cytotoxic activity. They reported that alpha beta unsaturated lactone variety in mycoepoxydiene might be

responsible for the cytotoxicity (Prachya S *et al.,* 2007). A study has been conducted on Hydro-methanolic extract (50%) of *Hydnocarpus anthelminthicus*, reported to inhibit enzymes involved in carbohydrate metabolism, rat intestinal sucrase and maltase by 5% and 25%, respectively, which is suggestive of antidiabetic activity (Anurakkun NJ *et al.,* 2007). A study has been conducted on analysis of seed oil containing cyclopentenyl fatty acids by combined chromatographic procedures. This study the fatty acids of the oils of Flocourtacecae, *Hydnocarpus anthelmintica, Caloncoba echinta* and *Taraktogenus kurzhii* has been examined by a combination of capillary gas chromatography,silver ion high performance liquid chromatography and gas chromatography-mass spectrometry (Christie WW *et al.,* 1989). A study has been performed on phytochemical investigations of *Hydnocarpus anthelminticus* reports the presence of two cyclopentenoid cyanohydrin glucosides, taraktophyllin and epivolkenin (Jaroszewski JW *et al.,* 1987). An investigation has been conducted on biosynthesis of cyclopentenyl fatty acids, cyclopentenylglycine a non-proteinogenic amino acid as precursor of cyclic fatty acids in Flacourtiaceae (Cramer U *et al.,* 1977). A study has been performed on the leaves of *Hydnocarpus anthelminthicus* are reported to contain minor amounts of cyclopentenyl fatty acids (0.5–1.5%) together with major fatty acids, such as palmitic, linoleic, and α-linolenic. Other major lipids reported include monogalactosyl diglycerides, digalactosyl diglycerides, and phosphatidyl cholines. The straight-chain monounsaturated fattyacids compriseprimarily Δ9 isomers, whereas the polyunsaturated fatty acids are the Δ9 series exclusively (Spener F *et al.,* 1975).

Hydnocarpus pendandra (Buch.-Ham.)Oken

Botanical Description

These trees are upto 10 m tall.Trunk &bark(figure4e) brownish, fissured; blaze pinkish. Branches & branchlets subterete, minutely pubescent. Leaves(figure4a) simple, alternate, distichous; stipules caducous; patiole 0.7-2.2 cm long, subterete, pubescent; lamina 8-23 × 3.5-10 cm usually oblong to elliptic-oblong, apex caudate-acuminate, base acute or cuneate, margin serrate, charactaceous, glabrous; midrib raised above; secondary nerves 5-7pairs,obliquely ascending towards apex; tertiary nerves closely horizontally percurrent. Flowers (figure4d) are in auxiliary short cymes or solitary, tomentose; petals white. Flowering takesplace from January to April. Fruit &seed(figure4b&c) are berry, woody, globose, apiculate 6-10 cm across usually brown tomentose, black when young; seeds numerous. Plant is endemic to the Western Ghats – very common in south and central sahyadris.

Chemical constituents

It contains epivolkenin, taraktophyllin. It contains six triterpenoids like ursolic acid, betulinic acid, acetylursolic acid, acetylbetulinic acid.

Medicinal properties

It is recommended for use in cases with leprosy abdominal distension with constipation, hemorrhoids sciatic, cervical Lymphadenitis, abdominal lump , fever, itching, worm infestation, diseases of skin inflammation, cases with metabolic disorder, disorders of the partial intestinal obstruction and ulcers.A work has been conducted on larvicidal potential of *Hydnocarpus pendandra* (Buch.-Ham.)Oken seed extracts against *aedea aegypti* Linn and *Culex quinquefasciatus* Say (*dipteral:culicidae*). The results clearly showed that the chloroform extract was the most effective treatment against both species (Sivraman G *et al.,* 2014).

A study has been performed on antibacterial and antioxidant properties of two medicinal plants *Hydnocarpus pentandra* and *E.triplinerveare*from kerala,India.It could be concluded that these two plants*Hydnocarpus pentandra* and *E.triplinerveare* potent sources of natural antioxidants with a free radical scavenging activity of 21.3 and 9.2 respectively and the methanollic extract of two plants inhibited the growth of *Escherichia coli* and *Bacillus subtilis* indicating that these plants have good antibacterial property (Shirona TK *et al.,* 2014). An investigation has been conducted on HPTLC analysis of the leaf extract of *Hydnocarpus pentandra*. The methanolic extract of leaf was subjected to phytochemical screening by HPTLC. The analysis revealed that the leaf is rich in phytochemical compounds like alkaloids, essential oils, flavonoids, flavonoid glycosides , phenolics , saponins steroids , tannins and triterpines (David T *et al.,* 2015). A study has been performed on the pharmacognostic evalution of dried leaf powder of *Cardiospermum halicacabum Linn* and dried seed hull powder of *Hydnocarpus pentandra*. In this study they investigated varies qualitative and quantitative parameters like microscopic evaluation of plant powder, physiochemical constants and preliminary phytochemical analysis. The pharmacognostic profiles of the selected plant materials were established and it can be used for the standardization of crude plant material with respect to quality, purity and identity (Suhas SN *et al.,* 2014). A study has been performed on the biochemical characterization of *Hydnocarpus pentandra* for seed oil quality, oil cake and its biodiesel production potential. Oil was collected from the seed by soxhlet extraction using hexane and fatty acid composition was checked by GC-MS. They concluded that hydnocapus has the potential to capture medicinal and biofuel sector due to its oil content and biodiesel production potential and for large afforestation programs in heavy rainfall areas (Dhathri NR, 2013). A comparison analysis study has been

conducted between neat diesel(petro-diesel) and neat *Hydnocarpus pentandra* (marotti) biodiesel has been carried out on a direct injection diesel engine. From the test results ,it could be noted that, neat marotti oil methyl ester(MOME) gives lower emissions such as hydrocarbon and oxides of nitrogen as compared to neat diesel for all load under steady state condition of the engine (Karthikeyan R *et al.,* 2009). A evaluation study has been performed on phytochemical constituents and anti-oxidant activity of Indian medicinal plant *Hydnocarpus pentandra*. In this study ethyl acetate and methanol extract were subjected to phytochemical screening and anti-oxidant studies. The total anti-oxidant and free radical scavenging activities of *Hydnocarpus pentandra* extracts were measured by ferric thiocyanate(FTC), thiobarbituric acid (TBA) and 1,1-diphenyl-2-picryl-hydrazyl (DPPH) methods. In case of radical scavenging activity, methanolic extracts showed 44% efficiency and 66% for ethyl acetate which was adequately comparable to the radical scavenging activity of the standard α-tocopherol (84%) (Krishnan S *et al.*, 2013). The*invitro* regeneration study has been conducted on *Hydnocarpus pentandra*. In this study the callus cultures were established from leaf plants on MS media supplemented with sucrose and varying amounts of auxins and cytokinins. They reported that callus initiation was observed with 2,4-D and NAA followed by incubation at 25 ± 2^0C under photoperiod of 16 hours (Hurakadle PJ *et al.,* 2011). A study has been conducted on endopytic fungi isolated from *Hydnocarpus pentandra*. In this study ten endiphytic bacteria were isolated from the plant. They reported that APEF-12,13 *Dematicious* sp, *Fusarium* sp showed maximum activity against *B.subtilis*, *E.coli* and APEF-06,15 *Cladosporium* species, non sporulating hyaline from showed activity against fungi (*C. albicans*) (Hurakadle PJ *et al.,* 2011). A work has been conducted on Novel cyclopentenoid cyanohydrins rhamnoglucosides from Flacourtiaceae. In this study, they worked on two novel cyclopentanoid cyanohydrin glycosides, (1S, 4 R)- and (1 R,4 S)-1-[6-O-(alpha- L-rhamnopyranosyl)-beta- D –glucopyrano syloxy] -4-hydroxy -2-cyclopentene-1-carbonitrile, were isolated from seeds of the Indian medicinal plant *Hydnocarpus pentandra* (Flacourtiaceae) and characterized by optical rotations as well as (1)H-and (13) C- NMR spectra. They found out structural assignment from the data and on degradation with alpha - L - rhamnosidase to the corresponding beta – D – glucopyranosides, epivolkenin and taraktophyllin, also present in the seeds in small amounts (Jaroszewski JW *et al.*, 1988)

***Hydnocarpus laurifolia*(Dennst) Sleummer**

Botanical Description

The tree grows up to a height of 10 m tall, is deciduous as well as ever green too. Bark is brownish, fissured; blaze pinkish. Branch lets are round in shape, minutely, velvet-hairy. Leaves (figure5)are simple, alternate, and carried on 0.7-2.2 cm long stalks. Leaves are 8-23 cm × 3.5-10 cm, usually oblong to elliptic-oblong, tip long-pointed, often falling off, base narrow, margin toothed, papery, and hairless. Midrib is raised above; secondary nerves of 5-7 pairs. Flowers are borne in short cymes or solitary in the leaf axils. Petals are white. Berry is woody, round, 6-10 cm across usually brown tomentose, and black when young; seeds were numerous. The flowering takes place from January to April. Flowers are greenish-white in color, grow solitary or recemes. The fruits are globose or ovoid, some 10 cm in diameter with a thick woody rind. Internally, they contain 10-16 black seeds embedded in the fruit pulp. The seeds account for some 20% of the fruit weight. Seeds obtusely angular, embedded in scants white pulp, and firmly adherent to the thin black testa. When the pulp is peeled off, the outer surface of the testa is seen to be rough and striated by shallow longitudinal grooves. Inside the shell is copious oily albumen, containing two large, plain heart-shaped and leafy cotyledons. The albumen when fresh is white but turns to dark brown color in the dry seeds.

Seeds are ovoid, irregular and angular, dorsiventral, slightly flattened, massive, lump-like, of various shapes, 2.54-3.175 cm long, 2.54 cm wide, and 0.4-0.5 cm in thickness toward the apex, skin is smooth, gray, and brittle; kernel oily and dark brown; hilum lies at a small circular elevation located at the base and micropyle adjacent to it. It has characteristic nauseous odor, acrid taste and oily on touch.

Chemical constituents

Chaulmoogric acid, hydnocarpic acid, palmitic acid.

Medicinal properties

It has antipyretic activity. Also used for leprosy and for various skin diseases. A work has been conducted on pharmacognostical characteristics of the seeds of *H. laurifolia* (Dennst) Sleummer. Seed shows the presence of crystalline masses of calcium carbonate, nonpitted sclereids and stone cells, spherical stone cells, aleurone grains, and fragment of tegmen. The work appears to be considered as reference standards for future studies (Jadav HR *et al.,* 2016). A study has been conducted about the beneficial effects of *Hydnocarpus laurifolia* seed on lipid profile status in streptozotocin induced diabetic rats. They estimated the fasting and post-prandal blood glucose levels by glucose-oxidase method and the plasma levels of cholesterol , triglycerides , low density lipoproteins and very low density lipoproteins were estimated. This study provided a rationale for the use of *Hydnocarpus laurifolia* seed extract as an anti-diabetic agent anti-

hyperlipidermic agent (Rao PS *et al.,* 2014). A study has been performed on the seed oil of *Hydnocarpus laurifolia*has been found to contain chaulmoogric, hydnocarpic, gorlic, lignoceric, palmitic, oleic, and stearic acids. Of these fatty acids, chaulmoogric and hydnocarpic are present in the highest amounts. A metabolism study of petroleum ether extract of the seeds in Sprague-Dawley rats revealed that the oil is metabolized and excreted from the body within 72 h of administration. No genotoxic effects were observed in bone marrow erythrocytes of Swiss mice when compared with methyl methane sulfonate (Sini H *et al.,* 2005).

***Hydnocarpus wightiana*Blume**

Botanical Description

This is a tree up to 10 m (33 ft) tall. The tree is deciduous and as well as evergreen too. Bark is brownish, fissured; blaze pinkish. Branch lets are round, minutely velvet-hairy. Leaves are simple, alternate, carried on 0.7–2.2 cm (0.28–0.87 in) long stalks. Leaves are 8 cm–23 cm × 3.5 cm–10 cm (3.1 in–9.1 in × 1.4 in–3.9 in), usually oblong to elliptic-oblong, tip long-pointed, often falling off, base narrow, margin toothed, papery, hairless. Midrib is raised above, secondary nerves 5−7 pairs. Flowers(figure6b) are borne in short cymes or solitary, in leaf axils. Petals are white. Berry is woody, round, 6–10 cm (2.4–3.9 in) across usually brown tomentose, black when young; seeds numerous The flowering takes place from to January to April. Flowers are greenish white in color and grow solitary or recemes.Trees of the species that yield Chaulmoogra oil grow to a height of 12–15 m (39–49 ft) and in India trees bear fruits in August and September. The fruits (figure6a)are ovoid some 10 cm (3.9 in) in diameter with a thick woody rind. Internally they contain 10-16 black seeds embedded in the fruit pulp. The seeds account for some 20% of the fruit weight. A typical tree produces 20 kg (44 lb) of seed/annum. The kernels make up 60−70% of the seed weight and contain 63% of pale yellow oil (mukherjee). The oil is unusual in not being made up of straight chain fatty acids but acids with a cyclic group at the end of the chain. Seeds are ovoid, irregular and angular, 1 to 1 1/4 inches long, 1 inch wide, skin smooth, grey, brittle; kernel oily and dark brown.It grows in tropical forests along western Ghats, along the coast from Maharashtra to Kerala, Assam, Tripura, often planted on road sides in hilly areas and also found in South East Asia, chiefly in Indo Malayan region. Cultivated in Sri Lanka, Nigeria and Uganda.

Chemical constituents

Oil contains hydnocarpic acid, isohydnocarpin, neohydnocarpin, methoxyhydnocarpin, chrysoeriol, chaulmoogric acid, gorlic acid, lower cyclic homologues, myristic acid, palmitic acid, stearic acid, palmitoleic acid, oleic acid, linoleic acid and linolenic acid. It contains alepric acid, aleprylic acid, aleprestic acid and aleprolic acid.

Medicinal properties

Internally and externally in the treatment of skin diseases, scrofula, rheumatism, eczema, also in leprosy, as a counter-irritant for bruises, sprains, etc., and sometimes applied to open wounds and sores.A study has been performed on the antidiabetic activity of ethanolic extract of *Hydnocarpus wightiana* Blume using Stz induced diabetes in SD rats. In this study they extended their work by administering in diabetes induced SD rats to check whether the extract has any antidiabetic activity. They found that the blood glucose levels got decreased when compared it with the first day of glucose levels and they confimed that the ethanolic extract of the seed hull of hydnocarpus has antidiabetic activity (Reddy JK *et al.,* 2013). A study has been performed on free radical scavenging, enzyme inhibitory constituents from antidiabetic ayurvedic medicinal plant *Hydnocarpus wightiana* Blume. In this study the acetone extract of seed hulls of *Hydnocarpus wightiana* posses strong free radicals (DPPH and ABTS) scavenging, alpha glucosidase and moderate N acetyl-beta-D-glucosamineidase inhibitory activities. This study suggests that presence of amphiphilic antioxidant molecules along with enzyme inhibitory activities in the acetone extract of *Hydnocarpus wightiana* seed hulls may be responsible for the antidiabetic properties as advocated in traditional medicine (Reddy SV *et al.,* 2005)

A work has been conducted and reported triterpenes, including acetylbetulinic acid, acetylursolic acid, betulinic acid, and ursolic acid, from the stem bark and leaves of *Hydnocarpus wightianus* plant (Nair SP and Rao MJ, 1993). A study has been performed on the hypolipidemic, anti- inflammatory and anti neoplastic activity and cytotoxicity of flavanoligans isolated from *Hydnocarpus wightiana* seeds. Hydnowightin, hydnocarpin, neohydnocarpin were isolated and potent hypolidemic activity, anti-inflammatory and anti-neoplastic activity was demonstrated in mice. Hydnocarpin and neohydnocarpin showed significant activity against T molt3 leukemia cell growth (Sharma DK and Hall IH, 1991). A study has been conducted on the surface lipids of *Hydnocarpus wightiana* leaves by thin layer chromatography and gas chromatography in conjunction with mass spectrometry. They reported that hydrocarbon fraction contained saturated n-alkanes, n-C35, with n-hentriacontane as major component and aldehyde fraction contained saturated n-alkanals,n-C23 to n-C32 with n-octacosanal as the major component. The surface lipids of *Hydnocarpus wightiana* leaves do not contain compounds having a terminal cyclopentene ring (Shukla VKS and Poulose MM, 1979). A work has been performed and reported the ^{13}C NMR flavanolignans from

Hydnocarpus wightiana and elucidated the structure of hydnocarpin, isohydnocarpin, hydnowightin, neohydnocarpin and methoxyhydnocarpin (Parthasarathy MR *et al.,* 1979). A study has been performed on screening of indigenous plants for anthelmintc action against human *Ascaris lumbricoids*: part-2. In this study alcoholic extracts of the seeds of *Hydnocarpus wightiana* showed good *in vitro* anthelmintic activity against human *Ascaris lumbricoids* , while, the alcoholic extracts of the bark of *Alibzzia lebbek*, the bulb of of *Allium sativum*, rhizomes of *Alpina calaratta*, rind of *Citrus acida*, rind of *Citrus aromatium* and rind of *Punica granatum* showed moderate *in vitro* activity (Raj RK, 1975). An investigation has been conducted on the fatty acid compositionof the seed oils of the species, *Hydnocarpus kurzii*, *Hydnocarpus wightiana* and *Hydnocarpus odorata* by gas-liquid chromatographic (GLC) analysis. The individual fatty acids were found to be : hydnocarpic, chaulmoogric, gorlic, lower cyclic homologues, myristic, oleic,linoleic, linolenic acids. A study has been conducted and analysed the chemical constitution of chaulmoogra oil of*Hydnocarpus wightiana* and reported the presence of alepric, aleprylic, aleprestic and aleprolic acids in it (Cole HI and Cardoso HT, 1939b).

***Hydnocarpus hainanensis*Merr. Sleum**

Botanical Description

Hydnocarpus hainanensis is an evergreen trees, reaching a size of 6-12m in height,of grey-brown bark; with teretes, hairless twigs.1-1.5 cm petiole;limbo usually oblong,less frequently closely elliptical,ovate or obovate slightly,from 9-18 ×3-6 cm,2-3 cm long wide, acute to obtuse or rounded, wedge shaped base,the serrulado margin or serrated. Inflorescence axially or sub terminal, 1.5-2.5 cm, with unisexual flowers(figure7c),15-20,as condensed(staminate flowers especially)in little stalked peaks. The fruit(figure7b) is a globose berry,4-5 cm in diameter, densely pale brown or yellowish tomentose dark, sometimes yellowish. Seeds ovoid,of 2.5 ×1.5-2 cm. Flowering in April. Fruiting in June-August. Located in E. Asia - southern China, Vietnam.

Chemical constituents

Chalmoogric oil, as taraktophyllin, hydnocarpic acid ,3,4-dihydroxybenzyl alcohol, 3,4-dihydroxybenzoic acid and 3hydroxy-4-methoxybenzoic acid.

Medicinal properties

A study has been conducted in fruits and seeds have a relatively high component of chaulmoogric oil, which is locally important for the treatment of skin conditions. A study has been performed on chemical constituents from fruits of *Hydnocarpus hainanensis* merr. (*Flacourtiaceae*) in Vietnam. Five compounds were isolated from the fruits of *Hydnocarpus hainanensis* Merr. Sleum. The isolates were identified as taraktophyllin, hydnocarpic acid , 3,4-dihydroxybenzyl alcohol , 3,4-dihydroxybenzoic acid and 3hydroxy-4-methoxybenzoic acid (Tra NT *et al.,* 2015). A work has been performed on significant inhibitory activity on the growth of the human glioma cell line U251 has been reported for the ethanol extract of *Hydnocarpushainanensis*, and is suggested for use as an antitumor drug (Jiangnan Y *et al.,* 2013). A study has been conducted on the chemical constituents from the leaf of *Hydnocarpushainanensis*. In the study the compounds were isolated and purified by silica gel and sephadex LH-20 column chromatography,their structures was identified by spectroscopic analysis. Nine components were isolated and identified asglutinol,fernenol,lupeol,a-armyrin,2,9-dimethyldeca-2,8 - diene, phytenal,phytol,3,7,11,15-tetramethyl hexad ecane- 1,2-diol,3,5-dimethoxy-4-hydroxybenzaldehyde (Li XJ *et al.,* 2012). A work has been conducted on the ethanol extract of the stem of *Hydnocarpus hainanensis* is reported to contain coniferaldehyde, mulberroside, mulberrofuran G, mulberrofuran, morusin, and daucosterol. From these compounds, coniferaldehyde have shown inhibitory activities on the growth of the human hepatoma cell line (SMMC-7721), the human gastric carcinoma (SGC-7901) and mulberrofuran G and morusin was active in SGC-7901 (Mei W *et al.,* 2013). A study has been performed on the stem *of Hydnocarpus hainanensis* compounds including wogonin, liquiritigenin, sapinofuranone B, (þ)-yangabin, phydroxybenzoic acid, and β-sitosterol have been isolated (Hui L *et al.,* 2011). An investigation has been conducted and reported a new phenolic glycoside from the stems of *Hydnocarpus hainanensis*. In this study a new phenolic glycoside was isolated from the stems of *Hydnocarpus hainanensis*, along with 11 known compounds. The anti-oxidation activities of several compounds were also evaluated (Shi HM *et al.,* 2008).

***Hydnocarpus annamensis* (Gagnep.) Lescot & Sleumer**

Botanical Description

Hydnocarpus annamensis is an evergreen tree that can grow from 8 - 25 m tall. Bark gray-brown; branchlets terete, gray-brown or reddish tomentose, winder bude ovoid-globose, scales brown tomentose outside. Petiole 1-2.5cm,brown tomentose; leaf blade green abaxially, deep green adaxially, obovate, elliptic-oblong or oblong-lanceolate,17-35×7-12cm,thinly leathery, abaxially sparsely hairy or hairy only along veins, adaxially shiy and glaborous, midvein raised on both sides, lateral veins 5-10 pairs, reticulate veins conspicuous, base broadly acute, cuneate, asymmetric, margin entire, apex obtuse contracting abruptly to a short acumen. Inflorescence axillary ; flowers solitary,2 or 3 together in cymes 1-2 cm, rachis pubescent. Pedicels 3-

5mm, together with penduncles densely brown tomentose. Sataminate flowers deep- green; sepals 4 or 5 ,orbicular,5-6mm,outside yellowish tomentose, inside glabrous; petals 4 or 5,suborbicular,outer petals 4-5 mm, inner ones smaller, both sides (excl,scale) glabrous, margin ±fimbriate;scale3-3.5mm axle hairy and fimbriate; stamens many(ca 25);filaments 4-5 mm hairy; anthers globose or subcordate, apex ± acute; pistillode absent. Pistillate flowers greenish,ca.1.5 cm in diam.;sepals 4,oblong 6-7mm, outside densely rusty tementose ,inside glabrous, margin ciliate; petals 8,suborbicular,innerones smaller outer ones larger, both sides(excl.scale) glabrous, margin ± fimbriate; scales as for staminate flowers; staminodes 8;ovary ovoid-orbicular, slightly 8-angled,densely pubescent, styles nearly absent, stigmas 4 or 5. Berry subglobose,4-6 cm in diam. Reddish or brownish tomentose interspersed with longer stiffer bristles, stigmas persistent, pericap cross-section with radially striate. Seeds numerous. Flowering april- may, fruiting january-december grows in moist mountain slpoes, thickets along streams;200-600 m.s.guangxi, s.yunnan [vietnam].

Chemical constituents

2-(3-benzoyl-β-D-glucopyranos yl)-5-hydroxy benzyl alcohol, 2-(4-benzoyl-β-D-glucopy ranosyl) -5-hydroxybenzyl alcohol, β-sitosterol, 40-hydroxypropiophenone, benzoic acid, (2S)-3-(4-hydroxy3-methoxyphenyl)-propane-1-one), daucosterol, syringaresinol-4O-β-D-glucoside,threo-10,20-guaicyl glyc erol 2-phenylpropane-1,3-diol, poliothyroside, junipetrioloside-A, cremanthodioside, salirepin thero-syrigoylglycerol 7-O-β-D-glucoppyranoside.

Medicinal properties

Leprosy and various skin diseases

A study has been performed on the enantiomer separation of the four diastereomers of guaiacyl glycerol from *Hydnocarpus annamensis* by capillary electrophoresis with HP –R-CD as a chiral selector. They reported that this method using capillary electrophoresis is powerful sensitive and fast and required small amount of reagents (Liu Y *et al*., 2007). A work has been performed on the separation of two isomeric neolignans by capillary electrophoresis to yield 1-(4-hydroxy-3-methoxy)-phenyl-2-[4-(1,2,3-tri-hydroxy-propyl)-2-meth oxy]-phenoxy-1,3-propandiol from *Hydnocarpus annamensis* bark (Shi HM *et al.,* 2007). A study has been conducted on the ethanol extract of the bark of *Hydnocarpus annamensis* chemical constituent, including phenolic glycosides, 2-(3-benzoyl-β-D-glucopyranos yl)-5-hydroxybenzyl alcohol, 2-(4-benzoyl-β-D-glucopyranosyl)-5-hydroxybenzyl alcohol, β-sitosterol, 40-hydroxypropiophenone, benzoic acid, (2S)-3-(4-hydroxy3-methoxyphenyl)-propane-1-one), daucosterol, syringaresinol-4O-β-D-glucoside,threo-10,20-guaicyl gly c er ol ,2-phenyl propane-1,3-diol, poliothyroside, junipetrioloside-A, cremanthodioside, salirepin thero-syrigoylglycerol 7-O-β-D-glucoppyranoside. Some of these compounds showed antioxidant activity and COX-2 inhibition (Shi HM *et al.,* 2006).

AVAILABLE SPECIES OF HYDNOCARPUS

Hydnocarpus alcalae C.DC	*Hydnocarpus merrillianus*
Hydnocarpus alpina Wight	*Hydnocarpus microcarpus*
Hydnocarpusannamensis (Gagnep.) Lescot & Sleumer	*Hydnocarpusmoluccana* Spreng.
Hydnocarpus annamica H.L. Li	*Hydnocarpus nana* King
Hydnocarpus anomalus (Merr.) Sleumer	*Hydnocarpusobtuse*
Hydnocarpus anthelminthica Pierreex Gagnep.	*Hydnocarpus octandra* Thwaites
Hydnocarpus anthelminthicus Pierre ex Laness.	*Hydnocarpusodoratus*
Hydnocarpus beccarianus Sleumer	*Hydnocarpus ovoidea* Elmer
Hydnocarpus borneensis Sleumer	*Hydnocarpus* palawanensis Merr. & Quisumb
Hydnocarpus calvipetalus Craib	*Hydnocarpus pentagynus* Slooten
Hydnocarpuscastanea Hook.f. & Thomson	*Hydnocarpus pentandrus* (Buch.-Ham.) Oken
Hydnocarpus cauliflora Merr.	*Hydnocarpus pinguis* Sleumer
Hydnocarpus clemensorum Gagnep	*Hydnocarpus piscidia*
Hydnocarpus corymbosa Seem.	*Hydnocarpuspolyandra* Blanco
Hydnocarpus crassifolius Sleumer	*Hydnocarpuspolypetalus* (Slooten) Sleumer
Hydnocarpus cucurbitina King	*Hydnocarpus punctifer* Slooten ex Den Berger
Hydnocarpus curtisii King	*Hydnocarpus quadrasii* Elmer
Hydnocarpus dawnensis C.E.Parkinson & C.E.C.Fisch.	*Hydnocarpus saigonensis* Pierre ex Gagnep.
Hydnocarpuselmeri Merr.	*Hydnocarpus scortechinii*
Hydnocarpus filipes Symington & Sleumer	*Hydnocarpus serrata* Warb.
Hydnocarpus glaucescens Blume	*Hydnocarpus setumpul* Slooten

Hydnocarpus gracilis (Slooten) Sleumer	*Hydnocarpus sharmae* P.S.N.Rao &Sreek.
Hydnocarpus grandiflorus	*Hydnocarpus stigmatophorus* Slooten ex Den Berger
Hydnocarpus hainanensis (Merr.) Sleumer	*Hydnocarpus subfalcata* Merr.
Hydnocarpus heteroclita Spreng.	*Hydnocarpussubinteger*
Hydnocarpus heterophylla Blume	*Hydnocarpussumatrana*
Hydnocarpushumei Ridl.	*Hydnocarpus sumatrana* (Miq.) (= *H. hutchinsonii*)
Hydnocarpushutchinsonii Merr.	*Hydnocarpus tamiana* Pulle
Hydnocarpus ilicifolia King	*Hydnocarpus tenuipetalus* Sleumer
Hydnocarpus inebrians Wall.	*Hydnocarpus tomentosa*
Hydnocarpus kingii Warb.	*Hydnocarpus unonifolia* Elmer
Hydnocarpus kuenstleri	*Hydnocarpus* venenata Gaertn
Hydnocarpuskurzii (King) Warb.	*Hydnocarpus verrucosus* C.E.Parkinson & C.E.C.Fisch.
Hydnocarpus laevis	*Hydnocarpus wightianus* Blume
Hydnocarpus lanceolata Spreng.	*Hydnocarpus woodii* Merr.
Hydnocarpus lasionema Airy Shaw	*Hydnocarpus wrayi* King
Hydnocarpus laurifolius	*Hydnocarpus* yatesii Merr
Hydnocarpus macrocarpa Warb.	

Fig 1. a.Leaf of *H.alpine*b.Fruit of *H.alpine*c.Bark of *H.alpine*

Fig 2. a. Leaf*H.kurzzi*

Fig 3. a.Flower of *H.anthelminticus*b.Fruit of *H.anthelminticus*c.Leaf of *H.anthelminticus*

Fig 4. a.Leaf of *H.pentandra*b&c.Fruit of*H.pentandra*d.Flower of *H.pentandra* e.Bark of *H.pentandra*

Fig 5. a.Leaf & fruit*H.laurifolia.*

Fig 6. a.Fruit of *H.wightiana* b.Flower of *H.wightiana*

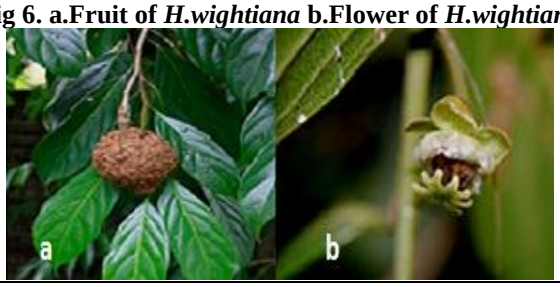

Fig 7. a.Leaf of *H.hainanensis*b.Fruit of *H.hainanensis*c.Flower of *H.hainanensis*

Fig 8. a.Leaf & fruit of *H.annamensis*

CONCLUSION

Furthermore it is concluded that most of the species in *Hydnocarpus* genus is widely used for leprosy and for various skin diseases. Even though there are around 40 species in the genus *Hydnocarpus* whichare indigenous to Asia's tropical rain forests, studies has been conducted only in few species. Exploring the remaining species of the genus can lead to the discovery of new compounds having medicinal value which will be beneficial for human life.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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