GENUS HYDNOCARPUS: A REVIEW

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ABSTRACT
There are around 40 species in the genus Hydnocarpus which are 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, Hydnocarpus kurzii 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.

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 Dioecous 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 40 species 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

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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, alternative, tonic, used as local application in rheumatism, sprains, braces 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, ascars, 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 streptomyacin – induced diabetic rats. The results obtained where compared with glibenclamide a standard hypoglycemic drug. The results suggested that the rhamnoside from *Hydnocarpus alpine* 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 *Hydnocarpus 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=C, -C=N, 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 *Hydnocarpus alpines* 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 kurzii (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%), garlic 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 garlic 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 chromato graphic
(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 (figure3a) 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, smoothing 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 pharmacognostic 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 (Jongrunguangchok S et al., 2013).

A work has been conducted on different extractions using n-hexane, ethyl acetate or n-butanol of seeds of *Hydnocarpus anthelminticus*, 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 fraction of *Hydnocarpus anthelminticus* 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 anthelminticus* and several compounds have been isolated from seeds of *Hydnocarpus anthelmintica* including p-hydroxybenzaldehyde, 4-hydroxy-3-methoxy benzoaldehyde, 5-hydroxyindole-3-aldehyde, ω-hydroxyxypropioguaiacone, evofofilin-B, dauosterol, oleanolic acid, chrysoeriol, 5,4-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 anthelminticus* seeds. In the study investigation on the extracts of *Hydnocarpus anthelminticus* 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 Flacourtiaaceae, Hydnocarpus anthelminthicus, Caloncoba echiota 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 anthelminthicus reports the presence of two cyclopentenoid cyanohydrin glucosides, taraktophyllin and epivolkkin (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 Flacourtiaeae (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 fatty acids comprise primarily 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; paticole 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 5-7 pairs, 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 epivolkkin, taraktophyllin. It contains six triterpenoids like ursolic acid, betulinic acid, acetylsorlic acid, acetylbetulinic acid.

**Medicinal properties**

It is recommended for use in cases with leprosy abdominal distension with constipation, hemorrhoids sciatric, 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 *aede aegypti* Linn and *Culex quinquefasciatus* Say (ditteral: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.triplinervear* from kerala, India. It could be concluded that these two plants *Hydnocarpus pentandra* and *E.triplinervear* potent sources of natural antioxidants with a free radical scavenging activity of 21.3 and 9.2 respectively and the methanolic 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 evaluation 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 soxhlextation 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 \( \alpha \)-tocopherol (84%) (Krishnan S et al., 2013). The in vitro 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°C under photoperiod of 16 hours (Hurakadle PJ et al., 2011). A study has been conducted on endophytic fungi isolated from Hydnocarpus pentandra. In this study ten endophytic 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 rhamnoglosucides 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-glucopyranosyl]-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, epivolkkenin 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 obously 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, aleurome 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-prandial 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-
A study has been performed on the seed oil of *Hydnocarpus laurifolius* 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 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, isohydncarip, neohydncarip, methoxyhydnocarip, 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, alepyric 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 confirmed 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* possesses 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 flavanolignans isolated from *Hydnocarpus wightiana* seeds. Hydnogwightin, hydnocarpin, neohydncarpin were isolated and potent hypolidemic activity, anti-inflammatory and anti-neoplastic activity was demonstrated in mice. Hydnocarpin and neohydncarpin 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-alkanal,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 Poulouse MM, 1979). A work has been performed and reported the 13C NMR flavanolignans from...
Hydnocarpus wightiana and elucidated the structure of
hydnocarpin, isohydnocarpin, hydnowightin, neoishydnocarpin and methoxyhydnocarpin (Parthasarathy MR et al., 1979). A study has been performed on
screening of indigenous plants for anthelmintic action
against human Ascaris lumbricoides: part-2. In this study
alcoholic extracts of the seeds of Hydnocarpus wightiana
showed good in vitro anthelmintic activity against human
Ascaris lumbricoides , while, the alcoholic extracts of the
bark of Alibizia 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, chaumoogric, garlic, lower cyclic homologues, myristic, oleic,linoleic, linolenic acids. A study has been conducted and analysed the chemical constitution of chaumoogra oil of Hydnocarpus wightiana and reported the presence of
alepric, aleplyric, aleprestic and aleprolic acids in it (Cole HI and Cardoso HT, 1939b).

Hydnocarpus hainanensis Merr. Sleum
Botanical Description

Hydnocarpus hainanensis is an evergreen tree,
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 x3-6 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 x1.5-2 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 chaumoogric 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. (Flacourtiaeae) 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
inhibitory activity on the growth of the human
glioma cell line U251 has been reported for the ethanol
extract of Hydnocarpus hainanensis, 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 Hydnocarpus hainanensis. 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, pytenal,phytol,3,7,11,15-tetramethyl hexad
econe- 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, mulberroseide,
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, (ß)-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,17-35x7-12cm,thinly
leathery, abaxially sparsely hairy or hairy only along
veins, adaxially shiny and glabrous, 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. Satinamine 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; scale=3-3.5 mm axile hairy and fimbriate; stamens many (ca 25); filaments 4-5 mm hairy; anthers globose or suborbate, apex ± acute; pistillode absent. Pistillate flowers greenish, ca. 1.5 cm in diam.; sepals 4, oblong 6-7 mm, outside densely rusty tomentose, inside glabrous, margin ciliate; petals 8, suborbicular, inner ones smaller, both sides (excl. scale) glabrous, margin ± fimbriate; scales as for stamine flowers; staminodes 8; ovary ovoid-orbicular, slightly 8-angled, densely pubescent, styles nearly absent, pericarp cross-section with radially striate. Seeds numerous. Flowering April-May, fruiting January-December grows in moist mountain slopes, thickets along streams; 200-600 m.s. guangxi, s. yunnan [vietnam].

Chemical constituents
2-(3-benzoyl-β-D-glucopyranosyl)-5-hydroxy benzyl alcohol, 2-(4-benzoyl-β-D-glucopyranosyl)-5-hydroxybenzyl alcohol, β-sitosterol, 40-hydroxypropophenone, benzoic acid, (2S)-3-(4-hydroxy-3-methoxyphenyl)-propene-1-one, dacosterol, syringaresinol-40-β-D-glucoside, theo-10,20-guayacil glycerol 2-phenylpropene-1,3-diol, polythiopyridine, junipetioloside-A, cremanthodioside, salirepin thero-syrigoylglycerol 7-O-β-D-glucopyranoside.

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- RCD 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-methoxy]-phenoxy-1,3-propanediol 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-glucopyranosyl)-5-hydroxybenzyl alcohol, 2-(4-benzoyl-β-D-glucopyranosyl)-5-hydroxybenzyl alcohol, β-sitosterol, 40-hydroxypropophenone, benzoic acid, (2S)-3-(4-hydroxy-3-methoxyphenyl)-propene-1-one, dacosterol, syringaresinol-40-β-D-glucoside, theo-10,20-guayacil glycerol 2-phenylpropene-1,3-diol, polythiopyridine, junipetioloside-A, cremanthodioside, salirepin thero-syrigoylglycerol 7-O-β-D-glucopyranoside. Some of these compounds showed antioxidant activity and COX-2 inhibition (Shi HM et al., 2006).

AVAILABLE SPECIES OF HYDNOCARPUS

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
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<tbody>
<tr>
<td>Hydnocarpus alcalae C.DC</td>
<td>Hydnocarpus merrillianus</td>
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<td>Hydnocarpus alpina Wight</td>
<td>Hydnocarpus microcarpus</td>
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<tr>
<td>Hydnocarpus annamensis (Gagnep) Lescot &amp; Sleumer</td>
<td>Hydnocarpus mollucanha Spreng.</td>
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<td>Hydnocarpus annamica H.L. Li</td>
<td>Hydnocarpus nana King</td>
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<td>Hydnocarpus anomalus Merr. Sleumer</td>
<td>Hydnocarpus obtusae</td>
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<td>Hydnocarpus anthelmintica Pierre ex Gagnep</td>
<td>Hydnocarpus octandra Thwaites</td>
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<tr>
<td>Hydnocarpus anthelminticus Pierre ex Laness.</td>
<td>Hydnocarpus dodonatus</td>
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<tr>
<td>Hydnocarpus beccarianus Sleumer</td>
<td>Hydnocarpus ooida Elmer</td>
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<tr>
<td>Hydnocarpus borneensis Sleumer</td>
<td>Hydnocarpus palawanensis Merr. &amp; Quisumb</td>
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<tr>
<td>Hydnocarpus calvitalus Craib</td>
<td>Hydnocarpus pentagynus Slooten</td>
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<td>Hydnocarpus castanea Hook. f. &amp; Thomson</td>
<td>Hydnocarpus fendlandii (Buch.-Ham.) Oken</td>
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<td>Hydnocarpus cauliflora Merr.</td>
<td>Hydnocarpus pinguis Sleumer</td>
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<td>Hydnocarpus clemensorum Gagnep</td>
<td>Hydnocarpus piscidia</td>
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<td>Hydnocarpus corymbosa Seem.</td>
<td>Hydnocarpus polyandra Blanco</td>
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<tr>
<td>Hydnocarpus crassifolius Sleumer</td>
<td>Hydnocarpus polypterus (Slooten) Sleumer</td>
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<td>Hydnocarpus cucurbitina King</td>
<td>Hydnocarpus punctifer Slooten ex Den Berger</td>
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<td>Hydnocarpus curtisii King</td>
<td>Hydnocarpus quadrasi Elmer</td>
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<td>Hydnocarpus elmeri Merr.</td>
<td>Hydnocarpus scortechinii</td>
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<tr>
<td>Hydnocarpus filipes Symington &amp; Sleumer</td>
<td>Hydnocarpus sarrata Warb.</td>
</tr>
<tr>
<td>Hydnocarpus glaucescens Blume</td>
<td>Hydnocarpus setumpul Slooten</td>
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</tbody>
</table>
Hydnocarpus gracilis (Slooten) Sleumer

Hydnocarpus grandiflorus

Hydnocarpus hainanensis (Merr.) Sleumer

Hydnocarpus heteroclitia Spreng.

Hydnocarpus heterophylla Blume

Hydnocarpus hainanensis (Slooten) Sleumer

Hydnocarpus subfalcata Merr.

Hydnocarpus subintegerr

Hydnocarpus sumatrana

Hydnocarpus sumatrana (Miq.) (= H. hutchinsonii)

Hydnocarpus tubifolius

Hydnocarpus tenuifolia Sleumer

Hydnocarpus tomentosa

Hydnocarpus unonifolia Elmer

Hydnocarpus venenata Gaertn

Hydnocarpus venenata Gaertn

Hydnocarpus voigtianus C.E.Parkinson & C.E.C.Fisch.

Hydnocarpus wightianus Blume

Hydnocarpus woodii Merr.

Hydnocarpus yatesii Merr

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

Fig 2. a. Leaf of *H. kurzii*

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. Fruit of *H. pentandra*. c. Flower of *H. pentandra*. d. Bark of *H. pentandra*
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* which are indigenous to Asia’s tropical rain forests, studies have 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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Dhathri NR. Biochemical Characterization of *Hydnocarpus pentandra* for seed oil Quality, Oil cake and its' Biodiesel production potential, 2013.


