Chapter 2

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REVIEW OF RELATED LITERATURE

2.1 ETHNOBOTANICAL STUDIES

Ethnobotany refers to the relationship between plants and human beings. According to Robins et al. (1916) ethnobotany deals with the study of plants used by primitive and aboriginal people. However, for Cunningham (2001) it is the scientific study that exists between people and plants. Ethnobotany aims to document the multiple uses of plants in human society and explains the complex relationship between the two in terms of how plants are used, managed and perceived for diverse needs such as food, shelter, medicine, clothing and textiles, cosmetics, natural dyes, hunting, agriculture and also in relation to rituals and religious ceremonies, the latter which forms a part of human social life.

The term ethnobotany was coined by John W. Harsberger, in 1896, who considered it as the art of collection of useful plants by a group of people and the description of the uses of these plants. Over the last century, ethnobotany has evolved into a scientific discipline that focuses on the people-plant relationship in a multidisciplinary manner, incorporating not only collection and documentation of indigenous uses but also ecology, pharmacology, public health, economy, and other disciplines (Gomez-Beloz, 2002). Presently ethnobotany has relevance in the field of health care and conservation programmes in different parts of the world (Balick, 1996).

In AD 77, Dioscorides documented the uses of 600 plants in his classical work, *De Materia Medica* (Chaudhary et al., 2008). Carolus Linnaeus in the 18th
century travelled to Samiland to study the Sami people and lived with them, wearing their cloths, sharing their food and documented the plants they used (Schultes, 1976). The British explorer and ethnobotonist Richard Spruce in the 19th century spent 17 years in the Amazon and Andes region of South America and discovered and hundreds of new plant species while also describing them. He conducted exploratory research on hallucinogens used by Amazonian tribes. Richard Evans Schultes (1976) in the 20th century made extensive research on useful plants like cocoa, palms, orchids and rubber. He conducted research among native American tribes in North Central and South America. He also conducted studies among the Mazatec people of South Mexico and documented the medicinal uses of mushrooms used by them for cardiac diseases.

In India the relationship between humans and plants can be traced back to prehistoric times. The science of botany was then known as *Vrikshayurveda* in India. The Indus Valley people who used to live in villages and towns wore cloths, cultivated crops, fruits and cotton, worshiped trees, glazed their pottery with the juice of plants and painted them with a large number of plant designs. In Vedic literature, there are descriptions regarding plants and plant parts, both external features and internal structures. Definite attempts at classification of plants were also done during that period. There are also evidences showing the practice of the use of manure and rotation of crops for the improvement of soil fertility and plant nourishment during the vedic period (Jain, 2013). Post-vedic Indian literature, however, shows that plant science developed as an independent science. The use of plants in worship, medicine, food, fuel and agriculture were mentioned in the ancient literatures viz., *Rig veda, Athar veda, Upanishads, Mahabharatha, Puranas* and several other post-vedic treatise (Sinha, 1996) and in traditional compendiums on medicinal science such as
Charaka samhitha (100 AD), Susrutha Samhitha (100-800 AD), Dwanwanthari Nighantu (1200) Nighantu Ratnakara, Kaiyadeva Nighantu, Osadhi varga and Ashtanga Hrudara (Sinha, 1996; Sharma and Dash, 1976; Atridev, 1975; Panday, 2001). The relevance of Arbori-Horticulture was illustrated in the ancient literature Upavana-vinoda (Majumdar G.P., 1935). Ancient Indian sages and scholars systematically categorised plants into various categories on the basis of occurrence, morphology and properties.

In India the ethnobotanical explorations were initiated under the leadership of Fleming (1810) and Chopra (1933). Another official programme was started by Janaki Ammal in 1954 in economic botany section of Economic Survey of India. A host of researchers such as Nayar et al., (1956); Nadkarni, (1955); Jain (1984, 1987, 1997); Maheshwari (1996) and Singh (2007) have contributed much to enrich the ethnobotanical knowledge in India.

In Kerala pioneer works on ethnobotany were initiated by Rheede (1678 – 1703) who compiled a compendium of the plants of economic and medical value in the Malabar region of Kerala. He used the ethno-medical information found in the palm leaf manuscripts of Itty Achuden, a famous herbal medicine practitioner in Malabar. Subsequent works were carried out by Ramachandran and Nair (1981), Pushpangadan and Atal (1984), Sivarajan and Balachandran (1994), Sajeev and Sasidharan (1997), Nayar et al. (1999), George et al. (2003), Manilal (2013), Mathur (2013), Jain (2013) and Rajith & Mohanan (2013).

2.1.1 GENUS HYDNOCARPUS IN MEDICINE

Medicinal use of Hydnocarpus can be traced back to Charaka Samhitha(AD 100), Susrutha Samhitha(AD 600), Dwanwanthari Nighantu (AD1200), Nighantu
Ratnakara, Kaiyadeva Nighantu, Osadhi Varga and Ashtanga Hrudaya (Sinha, 1996; Dogra et al., 2013; Panday, 2001). This genus was known by the name Tuvaraka, Katukapittha and Kusthavairi in Sanskrit. In India and China chaulmoogra oil, obtained from the seeds of Taraktogenos kurzii (Synonym: H. kurzii), was used for Hansen’s disease (leprosy) since 14th century (Wermager and Heltzel, 2007). The genus was included in the ancient Chinese literature Pen-Ts’ao Kang-Mu, published in AD 1596 as a remedy for leprosy (Bang, 2006). The chaulmoogra oil was reintroduced in India as a remedy for leprosy in 1874 (Parascandola, 2003; Skinsnes O.K., 1972). In the beginning of the 19th century Sir Leonard Rogers introduced sodium hydnocarparte commercially known as ‘ALEPOL’ in India which marked the beginning of leprosy control in India. (Rogers, 1920). Alice A. Augusta Ball, an African-American from Washington, developed the ethyl ester of the chaulmoogra oil in 1915, which was considered as a milestone in the treatment of Hansen’s disease (Wermager and Heltzel. 2007). In 1920 an Australian – American Botanist named Joseph Francis Rock explored the eastern mountains of India and discovered three species of Hydnocarpus and identified H. wightiana as the most potent source of chaulmoogra oil [“Joseph Francis Charles Rock. (1884-1962).”].

In 1908 Eric Fromm and J. Wittmann, chemists at the university of Freiberg, reported the synthesis of a chemical called Dapsone. But the therapeutic potentiality of this compound was unknown and untapped for three decades. In 1935 experiments on the therapeutic effect of Dapsone in animals showed promising antibacterial result. In addition Dapsone also showed severe haematological side effects which precluded its use in humans. In 1937 an American pharmaceutical company, Parke-Davis, refused to relinquish this potential drug and succeeded in the production of a non-toxic derivative called Promin, which was proved to be effective against tuberculosis.
As leprosy was biochemically similar to tuberculosis, it attracted the attention of the researchers. In 1941 Faget conducted clinical studies on human patients and proved the therapeutic potentiality of Promin against leprosy. In 1947, the Fifth International Congress on Leprosy abandoned chaulmoogra oil completely and adopted Promin as the standard treatment for leprosy (Barr, 2011). This discovery of Dapsone and Promin played a key role both in the case of leprosy and Hydnocarpus. The discovery of Promin provided a means for the permanent solution for leprosy, a non-curable disease in the ancient times, and many countries, including India, were successful in eradicating this disease. Due to the above mentioned reason, the genus Hydnocarpus was almost completely withdrawn from the therapeutic history of the world. Subsequently, the local people have started considering this genus as a useless one, which is the major reason for the threat to the genus in India, especially Kerala.

However, recently the genus has started regaining its therapeutic status. A number of studies have been reported by researchers. Jacobsen and Levi (1973), Kamat (2001) and Garcia et al. (2012) reported the antibacterial activity of the genus Hydnocarpus. Oommen et al. (1999) reported the wound and ulcer healing activity of the oil obtained from the genus. Amenta et al. (2000) reported the therapeutic activity of Hydnocarpus anthelmintica in the treatment of Psoriasis in China, while Charmi and Vimal (2012) reported the importance of Hydnocarpus laurifolia in ayurvedic formularies.

2.1.2 GENUS HYDNOCARPUS IN ECOLOGY AND AGRICULTURE

Besides the medicinal aspects a number of studies have been reported regarding the ecological and agricultural significance of the genus Hydnocarpus.
Chandrashekara (2011) reported the occurrence of *Hydnocarpus* as a common member in the sacred groves of Kerala. In another study, Clausen et al. (2002) pointed out the ecological importance of the genus by reporting it as a host plant for butterflies.

Chandrika et al. (2000) reported the pesticidal activity of *Hydnocarpus wightiana* Bl. against the coconut pests. In a similar investigation Vendan et al. (2010) reported anti-feedant and anti-larvicidal activities of *H. alpina*.

The review of the ethnobotanical literature carried out revealed that the genus *Hydnocarpus* has a significant role in medicine, agriculture and ecology. But most of the studies carried out on this aspect of the genus are based on species distributed in North Eastern India, Burma and China. Only limited studies are reported on the species present in Kerala and no studies have been reported regarding the religious and economic values of the genus. The studies reported were not sufficient to estimate the real value of the genus in Kerala. Hence, a detailed ethnobotanical investigation is necessary to identify the medicinal, agricultural, ecological, religious and economic values of the genus *Hydnocarpus* in Kerala and thereby provide a means for its conservation in Kerala. In this context, an earnest attempt is made by the investigator to explore in detail the ethnobotanical relevance of the genus *Hydnocarpus* in Kerala.

### 2.2 PHYTOCHEMICAL STUDIES

The detailed analysis of ethnobotanical literature revealed that not many studies were initiated to give value addition to the already known traditional uses of this genus. The review revealed that most of the phytochemical studies were done in line with seeds and seed oil, *chaulmoogra* oil, obtained from *H. kurzii* and *H. pentandra*. A
brief review of the phytochemical works carried out by earlier researchers is presented here.

Cole & Cardoso (1939) analysed the chemical constitution of *chaulmoogra* oil of *H. wightiana* and reported the presence of alepric, aleprylic, aleprestic and aleprolic acids in it. Mitra & Misra (1967) identified amino acids in the processed seed meal proteins of *Hydnocarpus*. Nair & Ramiah (1971) isolated the flavonoid compound, Leucopelargonidin, from *H. wightiana*. Ranganathan & Seshadri (1973, 1974) isolated new flavonolignans and minor phenolic compound namely, hydnocarpin, isohydnocarpin, methoxyhydnocarpin and chrysoeriol from the seed hulls of *H. wightiana*. In 1979, Parthasarathy, Rangathan, Sharma, Bhushan and Seshadri conducted extensive phytochemical research based on CNMR of flavonolignans and elucidated the structure of hydnocarpin, isohydnocarpin, hydnowightin, neohydnocarpin and methoxyhydnocarpin. Wemambu (1983) studied the bioactivity of the seed oil of *H. pentandra* and showed phagocytic activity in mice against *Myobacterium leprae* and substantiated its effectiveness in leprosy control.

In 1994, Saily et al. studied the mineral contents in *H. kurzii* (The Wealth of India. 2007). Rastogi & Mehrotra (1995) reported two new cyclopentanoid cyanohydrin glycosides isolated from the seeds and elucidated the structure of these compounds. They also reported the presence of epivolkenin and taraktyphyllin, chemical compounds like ursolic, betulinic, acetylbetulinic and acetylsersolic acid in the stem bark of *H. pentandra* and six new triterpenoids viz., octandrolal, octandrolool, octandrolic acid, octandronal, octandronol and octandronic acid, in the bark of *H. octandra*. 
Sini et al. (2005) reported the insecticidal action of the petroleum ether fraction of *H. laurifolia* seeds and identified the presence of fatty acids like, chaulmoogric acid, hydnocarpic acid, garlic acid, lignoceric acid, palmitic acid, oleic acid and stearic acid in it. The presence of flavonoids, apigenin, chrysoeriol, luteolin, fi-sitosterol, lupeol, fi-amyrin, betulinic acid and siterol-fi-D-glucoside in the seed hull of *Hydnocarpus wightiana* was also reported (Sharma, 2006).

Gupta et al. (2008) reported \((1S,4R)-1-[6-O-(\alpha-L-Rhamnopyranosyl)-\beta-D-glucopyranosyloxy]-1,4-dihydroxy-2-cyclopentene-1-carbonitrile\) and its \((1R,4S)\) isomer and other major phytochemicals identified by earlier researchers in his work entitles *Quality Standards of Indian Medicinal Plants*. Shi et al. (2008) reported a new phenolic glycoside, \(7,8\)-cis-\(8,8\)-trans-\(7,7\)-cis-\(7,7\)-bis-(4-hydroxy-3,5-dimethoxyphenyl)-\(8,8\)-dihydroxymethyl-tetrahydrofuran-9-O-D-glucopyranoside\) from the stem of *H. hainanensis*.

Many medicinal uses were attributed to *chaulmoogra* oil. Shah and Seth (2010) mentioned that the chemical constituents of *chaulmoogra* oil contains cyclopentanyl fatty acids like, hydnocarpic acid (48%), chaulmoogric acid(27%), garlic acid (6%) and oleic acid(12%). They also stated that the oil is strongly bactericidal towards the *Micrococcus* of leprosy.

Wang et al. (2011) isolated a new flavonolignan, anthelminthicol A, from the seeds of *H. anthelminthica* and elucidated its anti–inflammatory activity to inhibit nitric oxide production in LPS - stimulated RAW 264.7 macrophage cell lines. In a recent investigation, Krishnan et al. (2013) identified major classes of phytochemicals such as phenolics, carbohydrates, saponins and glycosides in the leaf extract of *H. pentandra* and studied the antioxidant activity of its methanolic extract. The presence of tannins, flavonoids, alkaloids and coumarin in the leaf extract of *Hydnocarpus*...
alpina and the antimicrobial, antidibetic, antifeedant and antilarvicidal activity of these secondary metabolites were investigated by Dhanasekaran et al. (2013). In another study Reddy et al. (2013) reported compounds such as flavonoids, glycosides, carbohydrates, amino acids, luteolin and hydnocarpin in the ethnolic extract of *Hydnocarpus wightiana* Blume. They also studied the inhibitory activity of the ethnolic extract against α-glucosidase in rats and its efficacy in treating diabetic complications. Arun & Kiran (2014) identified the presence of glycosides, flavonoids, carbohydrates, proteins, tannins, saponins, steroids and triterpenoids in the roots of *H. pentandra*.

On the basis of the above review it is concluded that only limited phytochemical studies have been conducted on the genus *Hydnocarpus*. Most of the earlier phytochemical studies were based on the chemistry of the seed and seed oil of *H. pentandra* and the species distributed in north eastern part of India and China. Hence a phytochemical investigation is necessary to identify the major group of phytochemicals in the genus. As revealed in the present review, no phytochemical studies have been conducted on different species of genus *Hydnocarpus* in Kerala. Hence, the present study aims to screen and compare the major groups of secondary metabolites in the leaves and bark of genus *Hydnocarpus* viz., *H. macrocarpa*, *H. pentandra*, *H. alpina* and *H. pendulus* in Kerala.

Preliminary investigation conducted by the investigator (David & Narasimhan, 2009) revealed that there is considerable ambiguity regarding the taxonomic position of *H. pendulus* and *H. macrocarpa*. Though chemotaxonomy is a reliable field which can provide ample evidences for resolving this ambiguity, no attempts have been reported on this aspect. In this context, the present study also aims
to provide a chemotaxonomic explanation to resolve the ambiguity that exists among
different species of genus *Hydnocarpus* in Kerala.

**2.3 PHARMACOGNOSTIC STUDIES**

“Pharmacognosy is defined as the scientific and systematic study of structural,
physical, chemical and biological characters of crude drugs along with their history,
method of cultivation, collection and preparation for the market” (Gokhale, 2000).

In recent years, people all over the world are becoming aware of the potency and side
effects of synthetic drugs. This situation has initiated interest and acceptance of plant-
based remedies with a basic approach towards the nature (Shah & Seth, 2010). The
plant-based medical systems still keep on providing the primary health care to more
than three quarters of the world population. The utilization of herbal drugs is on the
run and the market is growing day by day. The worldwide annual turnover for
traditional herbal medicines is around US dollars 60 billion. The annual turnover of
the Indian herbal medicinal industry is about Rs. 2300 crores as against the
pharmaceutical industries’ turnover of Rs. 14,500 crores with a growth rate of 15 %.
(Tilburt and Kaptchuk, 2008; Sharma et al., 2008). In this context, researchers are
now concentrating on exploring not only the classical plants but also related species
possessing similar and new phytochemical constituents with potential therapeutic
properties. Drug plants, standardized extracts and the therapeutically active pure
constituents have become a significant market commodity in international trade.

In India plant based medicinal systems have been in use since time
immemorial. The effectiveness of these systems chiefly depends upon sustained
availability and proper utilization of genuine raw materials. Global resurgence of the
awareness and increased dependence of people in herbal drugs has led to the need for
their mass production. Large scale production of medicinal plant product necessitated the availability of standards to ensure their quality, efficacy and safety. Inadequacy of quality standards has been a discouraging factor for many potential medicinal plants and is handicap in the herbal drug market (Gupta, 2008).

The future development of the herbal drug industry largely depends on the reliability of the methods adopted for standardisation and quality control of herbal drugs. Pharmacognosy provides a reliable means for standardisation of the herbal drugs as per the guidelines of WHO standards. Pharmacognostic tools also serve as reliable measure in the identification of disputed taxa when the primary morpho-taxonomic parameters fail to provide satisfactory evidences to delimit the taxa.

The pharmaceutical importance of genus *Hydnocarpus* is primarily based on the medicinally useful *chaulmoogra* oil extracted from the seeds of genus *Hydnocarpus*. In this context, pharmacognostic studies on the seeds of two species of *Hydnocarpus* viz., *H. pentandra* and *H. anthelminthica* were conducted by earlier researchers. Gupta et al. (2008) conducted macroscopic, microscopic and powder studies on the seeds of *Hydnocarpus pentandra* and developed the standards for the same. In another study, Oommen (2000) described the anatomical and powder characteristics of the seeds of *H. anthelminthica*. Metcalfe and Chalk (1972), Miller (1975) and Chauhan et al. (1995) conducted general studies on wood anatomy of genus *Hydnocarpus* in their anatomical work on family Flacourtiaceae.

Realising the inadequacy of the above mentioned studies, an earnest attempt was made by David & Narasimhan (2009) to characterise the morpho – taxonomic and wood anatomical features of the genus *Hydnocarpus* in South India. The study has brought to light common diagnostic features of the genus and species. The study
also revealed the morphological and anatomical resemblance seen among the different species in *Hydnocarous* in South India highlighting the need for further investigations to establish the pharmacognostic identity and evolutionary relationship of the genus.

In conclusion the review of related literature shows lacunae in describing the pharmacognostic relationship of the different species of genus *Hydnocarpus* in Kerala. Hence, the present study aims to fill that space based on detailed investigation on the anatomy of the leaves and petiole of different species viz, *H. macrocarpa*, *H. pentandra*, *H. alpina* and *H. pendulus*.

**2.4 CONCLUSION**

In conclusion the reviews carried out with respect to ethnobotany, phytochemistry and pharmacognosy revealed the need for further studies on these aspects to bring out the ethnobotanical relevance, evolutionary relationship, pharmacognostic and phytochemical similarities, bioprospecting and conservation priorities of the genus *Hydnocarpus* in Kerala. It is expected that the study will contribute to provide value addition to the genus *Hydnocarpus* in terms of ecological conservation, agricultural sustainability and promotion of indigenous plant-based industries.