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Review Article

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History and Taxonomy of *Aegle marmelos*: A Review

Nidhi Sharma* and Widhi Dubey
School of Pure and Applied Sciences, JECRC University, Jaipur-303905, Rajasthan
*Corresponding Author E-mail: sharma.nidhi0789@gmail.com

ABSTRACT

Plant medicine system is attracting more attention than the allopathic system nowadays, as this system is pollution free, less toxic and without side effects. The dependency on plants urged human beings to identify and classify the plants into different groups such as food plants, poisonous plants and medicinal plants. This study includes the evolutionary history of plant taxonomy showing its importance in day to day life and a review of taxonomic positioning of Aegle marmelos fruit plant which has immense medicinal properties. It belongs to the family Rutaceae. Taxonomic study of any plant makes it easier to identify the other important plants from the same taxonomic groups.

Keywords: *plant medicine, allopathic system, taxonomy, Aegle marmelos, Rutaceae.*

INTRODUCTION

Men from time immemorial have been dependent on the plant world for innumerable needs. This dependency on plants urged him to identify and classify the plants into different groups, such as food plants, poisonous plants and medicinal plants. This led to the beginning of plant taxonomy[1].

The history of plant classification is an interesting subject. AP de Candole (1778-1841) coined the term 'taxonomy' for the first time. Plant taxonomy has a long history as it plays its central role in biology and human affairs. The first recorded document in the western world on plants and their relationships come from the Ancient Greeks. Theophrastus (c. 300 BC) wrote several manuscripts which have been published later as books dealing with plants. His most remarkable work, *Enquiry into Plants*, sets down many morphological aspects, including their growth and reproduction system. But it could not give a clear understanding of plant sexuality. Taxonomists like Andreas Caesalpino from Italy, Gaspar Bauhin from Switzerland, John Ray from England and Josef Pitton de Tournefort from France led to the positive developments for classification of medicinal plants. Their objective was to reveal classification system of god, used at the time of creation. Carl Linnaeus (1707-1778), the great Swedish botanist and 'father of plant taxonomy', extended this perspective and believed that the number of sexual structures in a plant – the stamens and carpels – was the signature that God had for their proper classification[2]. The first half of the 19th century was important in the history of taxonomy, as a number of systems of classification were put forward during this time. The oldest types of data are based on the morphology including external features. Further, with the invention of microscopes in the sixteenth century; studies of the internal structures of plants provided details of their anatomy and embryology. In the early decades of the twentieth century, stronger microscopes led the use of cytological features, especially chromosomes. The study of pollen grain and its potential in plant taxonomy were explored further due to the use of transmission electron microscopes in 1950s and scanning electron microscopes in 1970s. Use of secondary metabolites in plants, especially flavonoids, mono- and sesquiterpenoids, alkaloids, betalain became important in 1960s and 1970s.

The above illustration of the history of plant taxonomy shows that people have always needed to classify the living world. According to T.H. Huxley (1869), by the classification of any series of objects the actual, or ideal arrangement, together of those which are like and the separation of those which are unlike is done. The purpose of this arrangement is to facilitate the easy retention of the characters of the objects in mind which are in question[3]. Benefits of classification include storage, retrieval of information, allows us to predict attributes of organisms not yet observed or measured. If we find, for example, a secondary plant product from some plant species that shows activity in inhibiting growth of cancerous cells, we would wish to investigate related species (or genera) to discover similar compounds with perhaps even greater potency[4].

Due to the increasing awareness among the people towards natural products, natural medicine is attracting more attention than the allopathic system. Moreover, this system of medicine is pollution free and less toxic without side effects. Out of the 6000 plants mentioned in the traditional systems of medicine, only 350 species are under use. *Aegle marmelos* (L.) Corr., belonging to the family Rutaceae is one of them, which plays a vital role in day to day usage. It is an important aromatic medicinal tree of Indian origin. Almost all parts of bael tree are used in preparing herbal medicines. This plant is very significant for ethnomedicinal and religious purposes[5].

Rutaceae comprises of some 158 genera and 1900 species[6]. It is sub cosmopolitan with major centres of diversity in Southern Africa and Australia and widely distributed in both temperate and tropical zones of the new as well as the old world. In India, it is represented by 23 genera and over 80 species occurring mostly in the tropical and subtropical Himalayas and the western peninsular India. Bentham and Hooker (1965) included Rutaceae in Geraniales and so did Engler and Diels (1936). But Melchior (1964) regarded it as a member of a separate order Rutales and placed it next to the Geraniales. Rendle (1925) and Hutchinson (1973) also placed Rutaceae in Rutales but the circumscription of the order varied. Engler (1896, 1931) produced the only comprehensive monograph of the family within the last century using gynoecial and fruit characteristics to recognize seven subfamilies: Rhabdodendroideae, Aurantioideae, Flindersioideae, Spathelioideae, Dictyolomatoideae, Rutoideae and Toddalioideae. Late twentieth-century classifications (Hutchinson, 1973; Takhtajan, 1997; Dahlgren, 1989; Thorne, 1992; Cronquist, 1993) have excluded Rhabdodendroideae from Rutaceae, now recognized as Rhabdodendraceae (Caryophyllales; APG, 1998), whereas the other six subfamilies, not always with the same circumscriptions have been largely retained. Of recent arrangements, Hutchinson's classification (1973) was the most distinctive in that he recognized only four subfamilies: Rutoideae, Toddalioideae, Rhabdodendroideae and Aurantioideae, omitting Spathelia (Spathelioideae) and Dictyoloma (Dictyolomatoideae) without a stated justification. Takhtajan (1997) recognized the six subfamilies, while Thorne (1992) merged Toddalioideae with Rutoideae, making five, but neither Dahlgren (1989) nor Cronquist (1993) recognized any subfamilies. The most recent higher-level classification of Rutaceae is that of Thorne (2000), who recognized three subfamilies: Rutoideae (including Chloroxylon, Flindersia, Luvunga, Toddalioideae; 120 genera), Aurantioideae (30 genera), and Spathelioideae (including Dictyolomatoideae; five genera); he excluded Rhabdodendroideae as a distinct family. In the Thorne (2000) system, the largest groups within Rutaceae are Aurantioideae and Rutoideae (including Toddalioideae). Engler distinguished them by their syncarpous ovary with one or two, sometimes several, ovules per carpel; their indehiscent, fleshy fruits with a soft, parenchymatous pericarp bearing schizolysigenous oil glands, sometimes with a hard exocarp, as in *Aegle* and *Swinglea*; often with pulp vesicles in the locules; and the endosperm lacking; seeds often with two or more embryos.

Order Rutales

The order rutales comprises of 3 suborders:

a) Suborder Rutineae includes 6 families

b) Suborder Malpighiineae 3 families, and

c) Suborder Polygalineae 2 families.

Members of the Rutales are mostly trees and shrubs. Few of these members are climbers and herbs also. In the family Rutaceae of this order, leaves are simple or pinnately or palmately compound, mostly estipulate, often glandular-punctate. Inflorescence is much variable, flowers are usually actinomorphic, scented and with a nectariferous interstaminal disc which is absent in Polygalineae. Embryologically and anatomically, these families are allied. Pollen grains are monads and usually shed at 2-celled stage. Ovules are mostly bitegmic, crassinucellate, and anatropous, hemianatropous or epitropous. Within the order, Rutaceae are grouped with Simaroubaceae, Meliaceae, Cneoraceae, and Ptaeroxylaceae, primarily because of the absence of resin ducts in the bark, wood rays, and leaf veins and the presence of triterpenoid compounds (Cronquist, 1988). However, members of Rutaceae are distinguished from these families, by glandular-punctate leaves, the production of limonoids, and the usual presence in parenchyma and pericarp of secretory cavities containing aromatic ethereal oils[7].

Identifying Features of Rutaceae

Species of Rutaceae are distinctive and easily recognizable because of their often opposite, compound, pellucid-punctate leaves; cymose inflorescences, polypetalous flowers with stamens having thick filaments. These filaments form a ring and vary with a conspicuous disc at the base and the stigma is expanded. Fruits mostly have a glandular-punctate pericarp, some being fleshy and indehiscent, while others are dry and dehisce to reveal shiny black seeds[7].

Most species are trees, shrubs and a few are herbs. Some herbs like *Boenninghausenia* and *Dictamnus* are frequently aromatic with glands on the leaves, sometimes with thorn-winged petioles. Leaves are usually without stipules but gland-like stipules present in some species of *Eriostemon* and *Philotheca*. Pellucid glands, a type of oil containing cavities, are found on the leaves responsible for the aromatic smell of the family's members. Traditionally, they have been the primary synapomorphic characteristics to identify family Rutaceae[8].

Rutaceae contain many members of economic importance. The well known examples of the family are lemon (*Citrus limon*), malta or sweet orange (*C. sinensis*), shaddock (*C. maxima*), bael fruit (*Aegle marmelos*), kamini or orange jasamine (*Murraya paniculata*). Most notable are the species of *Citrus* that produce the citrus fruits, e.g., lemons, oranges, mandarins, tangerines, limes, kumquats and the essential oils used in perfumery, the species of *Pilocarpus* that are the source of pilocarpine, a drug used to treat glaucoma, and the species of *Boronia*, *Choisya*, *Poncirus*, and *Skimmia* that are used as ornamentals[7]. *Aegle marmelos*, which is also a medicinally important genus of this family, adapt a wide range of habitat from arid, semiarid to mesophytic conditions.

Systematic Position of *Aegle marmelos* [9]

Bentham and Hooker	**Engler & Prantl**	**Hutchinson**
Dicotyledones	Dicotyledoneae	Dicotyledones
Polypetalae	Archichlamydeae	Lignosae
Disciflorae	Geraniales	Rutales
Geraniales		

DISTRIBUTION

Aegle marmelos is a subtropical plant which can grow up to an altitude of 1200 m from the sea level. It grows well in the dry forests of hilly and plain areas. *A. marmelos* can adapt a wide range of habitat and can be cultivated worldwide. It is native to India and has its origin from Eastern Ghats and central India. This tree is mentioned in the pre-historic writings dating back to 800 B.C. The Chinese Buddhist pilgrim, Hiuen Tsiang, when came to India (1629 A.D.), noticed the presence of this tree in India[10]. It is cultivated throughout India and due to mythological importance; it is mainly grown near the temples. It grows wild in dry forests on hills and plains of central and southern India, Sub-Himalayan tracts from Jhelum eastwards to West Bengal, The Deccan Plateau, the East coast, and also found in Andaman Islands. It found almost in all the states of India such as in Andhra Pradesh, Bihar, Himachal Pradesh, Jammu and

Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal[11]. In West Bengal, there are 13 types of fruits in *Aegle marmelos* based on the fruit's morphology. The fruits were grouped under five categories; oval, flat, spherical, oblong and pear shaped and in each group three subgroups (small, medium, big) were separated. It is also cultivated in Nepal, Myanmar, Tibet, Ceylon, Vietnam, Laos, Cambodia, Sri Lanka, Bangladesh, Thailand, Indonesia, Malaysia, the drier areas of Java, Fiji and to a limited extent on Northern Luzon of Philippine Islands where it first fruited in 1914[12,13,14]. It is grown in Surinam and Trinidad, and some gardens of Egypt. In the 1500's this fruit was resorted to by the Portuguese in the East Indies and later by British colonials as a means of remedy to treat diarrhea and dysentery. It has grown well and fruited on the oolitic limestone of Southern Florida. Bael fruit was introduced in Europe in 1959[15].

Local Names

Burmese (Opesheet, Ohshit); English (Bael Fruit, Indian Bael, Holy Fruit, Golden Apple, Elephant Apple, Bengal Quince, Indian Quince, Stone Apple); German (Belbaum, Schleimapfelbaum, Baelbaum); Gujarati (bili); Hindi (baelputri, bela, sirphal, siri-phal, kooralam); Indonesian (maja batuh, maja); Javanese (modjo); Khmer (bnau); Lao (Sino-Tibetan) (toum); Malay (bilak, bel, bila, maja pahit); Portuguese (marmelos); Thai (matum, mapin, tum); Vietnamese (trai mam, mbau nau)[16].

Botanical Description

Aegle marmelos is a slow-growing, medium sized tree, up to 12-15 m tall with short trunk. Its bark is thick, soft, flaking and spreading. Branches are spiny in some varieties, the lower ones are drooping. A clear, gummy sap, resembling gum arabic, exudes from wounded branches and hangs down in long strands, becoming gradually solid. Taste of this gum is sweet at first but later irritating to the throat. The leaves are deciduous, alternate, borne singly or in 2's or 3's oval, pointed, shallowly toothed leaflets, 4-10 cm long, 2-5 cm wide and the terminal one with a long petiole. New foliage is glossy and pinkish-maroon. Mature leaves emit a disagreeable odour when bruised. Flowers are fragrant having sweet aroma and blooms in clusters of 4 to 7 along the young branchlets. Each flower has 4 curved fleshy petals which are green outside and yellowish inside, and 50 or more greenish-yellow stamens. Shapes of the fruits can vary with varieties and can have round, pyriform, oval, or oblong shapes having 5-20 cm diameter. Fruit may have a thin, hard, woody or soft rind. It is dotted with minute oil glands which are aromatic. Inside the fruit, there is a hard central core and 8 to 20 faintly defined triangular segments, with thin, dark-orange walls. These segments are filled with aromatic, pale orange, pasty, sweet, resinous, more or less astringent pulp. 10 to 15 seeds are embedded in the fruit pulp. Seeds are flattened-oblong, about 1 cm long, bearing woolly hairs and each enclosed in a sac of adhesive, transparent mucilage that solidifies on drying[17].

Ecology

The tree grows wild in dry forests on hills and plains of central and southern India, Burma, Pakistan and Bangladesh, also in mixed deciduous and dry dipterocarp forests. *A. marmelos* is a subtropical species. It is found all over India. In Punjab, it grows up to an altitude of 1,200 m where the temperature rises to 48.89º C in the shade in summer and descends to -6.67º C in the winter, and prolonged droughts occur. It will not fruit where there is no long, dry season as in southern Malaysia[18].

Soil Type: *A. marmelos* is said to do best on rich, well-drained soil, but it has grown well and fruited on the oolitic limestone of southern Florida. It also grows well in swampy, alkaline or stony soils having pH range from 5 to 8. In India it has the reputation of thriving where other fruit trees cannot survive[17]. This tree requires pronounced dry season to give fruit. This tree is also used as food for the larva of following 2 Indian swallow tail butterflies;

- The Lime Butterfly: Papilio demoleus
- The Common Mormon: Papiliopolytes[19, 20, 21,]

Fig: *A. marmelos* fruits (Unripe, Ripe and Transverse section)

Fruit Cultivars of *Aegle marmelos*

There are no standardized names for *A. marmelos* cultivar. They are given names on the basis of locality where these are found. Fruits of different cultivars were of different shapes and sizes, such as spherical, oblong, cylindrical, pear-shaped and flat. Fruit weight also varied in different cultivars. The percentages of peel, seeds and contents of other fibres also varied. There are reports available on the cultivars of bael mainly from Uttar Pradesh and Bihar states of India[22, 23].

Around twelve cultivars, viz., 'Basti No.1', 'Gonda No.1', '2' and '3', 'Kagzi Etawah', 'Sewan Large', 'Deoria Large', 'Chakaiya', 'Lamba', and 'Baghel' has been reported. 'Kagzi Etawah', 'Sewan Large', 'Deoria Large' and 'Mirzapuri', have been found to be superior and better than the other varieties in case of taste and qualities. S.K. Roy in 1975 studied 24 cultivars from four different locations in India- Agra, Calcutta, Delhi and Varanasi and mainly focused on their extreme variability. He selected and evaluated the different cultivars for high sugar content and low levels of mucilage, tannins and other phenolics[24]. 'Kaghzi' is one of the esteemed large cultivar with thin rind and few seeds. Dr. L.B. Singh and his co-workers at the Horticultural Research Institute, Saharanpur, India, surveyed bael fruit trees in Uttar Pradesh and screened about 100 seedlings, selected as the most promising for commercial planting are 'Mirzapuri', 'Darogaji', 'Ojha', 'Rampuri', 'Azamati', 'Khamaria'. Out of all these, the best rated was 'Mirzapuri', with very thin rind, breakable with slight pressure of the thumb, pulp of fine texture, free of gum, of excellent flavor and contain less amount of seeds.

Four cultivars *viz.*, 'Narendra Bael-4' 'Narendra Bael-5', 'Narendra Bael-7' and 'Narendra Bael-9' have been identified and studied by Srivastava and Singh from "Narendra Deo University of Agriculture and Technology", Faizabad, in 2004. They experimented to evaluate these commercially important cultivars and found that the heaviest fruit weight was recorded in 'Narendra Bael-7', whereas minimum fruit weight, fruit length and fruit breadth recorded was of 'Narendra BaeI-4'. Fibre content and seed/fruit were recorded minimum in 'Narendra Bael-9' and maximum in 'Narendra Bael-5'. Maximum total soluble solid, ascorbic acid and total sugar content recorded in 'Narendra Bael-5'. Though, minimum total soluble solids, ascorbic acid and total sugars were recorded in 'Narendra Bael-7'[25].

A number of cultivars have been selected recently which are the best among the others with regards to yield and fruit quality. These are;

'NB 5'—Fruit size is medium, round in shape having smooth surface at maturity, low mucilage, moderately fibrous and have soft flesh with excellent taste.

'NB 6'—Fruit size is medium, round with smooth surface, and have thin rind, few seeds, soft flesh, low mucilage and mild acidic.

'Pant Shivani'—Mid season cultivar with ovoid oblong shape, size 2 kg, colour lemon yellow on ripening, fiber and mucilage content medium, rind medium thick, pulp light yellow with very good taste and pleasant flavour.

'Pant Aparna'—late cultivar with small fruit size (0.6 - 0.8 kg), globose shape, and seed, mucilage, fibre and acidity are low. Its Flesh is yellow, sweet, tasty and having good flavour.

Fig: B. Bael Fruits of Various Shapes and Sizes from Jaipur Region

CONCLUSIONS

Beginning of plant taxonomy came into the existence with the need of identifying and classifying the plants which were important for humans because men from time immemorial have been dependent on the plant world for innumerable needs. Various classification systems have been put forward for placing the plants having similar characteristic features. *Aegle marmelos* is one of those important plants which have medicinal as well as other properties. It has been placed in family Rutaceae which is also known as citrus family. This study provides the important evolutionary steps of plant taxonomy which can further help us to provide information about the plants which are still to be identified and classified whether as medicinal, food or poisonous plants, by means of identifying their various features similar to particular taxonomic groups.

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