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Comprehensive Dossier on Ayurvedic Medicinal plant *Aegle marmelos* (L.) Corrêa. : A Review

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Abstract *Aegle marmelos* (L.) Corrêa is a medicinal and dietary plant species with traditional and folk uses since millennia. Numerous numbers of phytochemicals present in the plant are responsible for diversified pharmacological activities. Brief discussions on plant pharmacognosy, pharmacology are included in this article. The authors of this review put an immense emphasis on phytochemicals isolated from the plant. The article also summarizes the extensive study of spectral data on phytochemicals.

Keywords Pharmacognosy, Pharmacology, Therapeutic activity, Chemical constituents, NMR

1. Introduction

The genus Aegle belongs to family Rutaceae and marmelos is the most commonly encountered species in biological and chemical studies. Another species *Aegle decandra* (syn. *Swinglea glutinosa*) is less studied under botany of citrus [1]. In Indian subcontinent *Aegle marmelos* is commonly known as 'bael' also known as 'golden apple'. It has been observed to be used in human health benefit since Vedic era. The plant is the natural habitat of Indian Subcontinent. It is also found in the Indo-China (Myanmar), North Indian Ocean (Andaman & Nicobar). Its massive contribution towards human health motivates the cultivation of the plant in South East Asia. The source of folklore medicines, gums, resins, essential oils, woods, make the plant economically important [2]. The principal metabolic classes of compounds present in the plant are coumarinoids, flavonoids, alkaloids, terpenoids, steroids, tannins etc. Every parts of the plant are rich source of phytochemicals like steroids, coumarinoids, terpenoids, alkaloids, tannins etc. The pharmacological studies of the different parts of the plant claim several activities including hepatoprotective, antidiarrhoeal, antimicrobial, antifungal etc.

2. Origin & Distribution

The bael tree has its origin from Eastern Ghats and Central India. It is indigenous to Indian subcontinent and mainly found in tropical and subtropical regions. The tree is also found as a wild tree, in lower ranges of Himalayas up to an elevation of 500 meters to West Bengal. Bael is found growing along foothills of Himalayas, Uttar Pradesh, Bihar, Chhattisgarh, Uttaranchal, Jharkhand, Madhya Pradesh, and the Deccan Plateau and along the East Coast, Myanmar, and Srilanka [3].

Hiuen Tsiang, the Chinese Buddhist pilgrim who came to India in 1629 A.D. noticed the presence of this tree along with other trees in this region. It is also grown in some Egyptian gardens in Surinam and Trinidad. Specimens of Bael are procured and maintained in Citrus collection in Florida. Bael fruit has been used traditionally in making paints in Burma. In Bangladesh the tree has been used for fertility control and antiproliferative, and in Sri Lanka it has been used for its hypoglycemic activities. Bael fruit was introduced in Europe, in 1959. The tree has also been

reported to be cultivated in Ceylon, Northern Malaya, Java and Philippine Island where it was first fruited in 1914 [4].

Soil Type: Bael grows best on rich, well drained soil, also in swampy, alkaline and stony soils having pH range from 5 to 8. In India, it has the reputation of thriving where other fruit trees cannot survive. It has grown well and fruited on the oolitic limestone of Southern Florida [5]. The common names [6-8] used worldwide for this plant are given Table 1.

Table 1: Common names of *Aegle marmelos* in different languages across the globe

Language	Name	Language	Name
Bengali (India)	Bel	Malay	Pokok Maju Batu
Burmese	Ohshit, Opesheet	Marathi (India)	Kaveeth
English	Bengal quince	Nepali	Bel, Gudu
French	Oranger du Malabar	Orissa (India)	Belo
Gujrati (India)	Billi	Portugese	Marmelos
Hindi (India)	Bael, Sreephal	Sanskrit (India)	Shreephal, Bilva, Bilwa
Indonesian	Maja batuh, Maja	Tamil (India)	Vilva Maram, Vilva Pazham
Javanese	Modjo	Telugu (India)	Maredu
Khmer	Bnau	Thai	Mapin, Matum, Tum
Lao	Toum	Urdu (India)	Bel
Latin	*Aegle marmelos*	Vietnamese	Mbau Nau, Trai mam

3. Taxonomical, Botanical, Pharmacognostical Descriptions (leaves, fruits, seeds, bark, root)

3a. Taxonomical Status: Taxonomical classification [9] of Aegle marmelos is given in Table 2.

Table 2: Taxonomical status

Rank	Scientific Name
Kingdom	Plantae
Subkingdom	Viridiplantae
Infrakingdom	Streptophyta
Superdivision	Embryophyta
Division	Tracheophyta
Subdivision	Spermatophytina
Class	Magnoliopsida
Superorder	Rosanae
Order	Sapindales
Tribe	Clauseneae
Genus	*Aegle* Corrêa
Species	*Aegle marmelos*

3b. Botanical Description:

Indian bael (*Aegle marmelos*) is a deciduous slow growing armed tree with straight sharp 2.5 cm long, axillary thorns, attaining 6 to 15 meters in height with short trunk, thick, soft flaking stem bark, as pieces of flat or channeled, about 0.5 to 1 cm thick, grey in color, surface rough and warty due to a number of lenticels, ridges and furrows; fracture tough, gritty in outer and fibrous in inner region; stem spreading sometimes spiny branches, the lower ones drooping. branchlets cylindric, sometimes slightly angled, glabrous; spines axillary, solitary or paired, straight, stout and sharp, if a pair of spine is present the arms are either equal or unequal. Spine length 2-3 cm [10].

Leaves are alternate, dimorphic, trifoliate, rarely pentafoliate, leaflets acuminate and aromatic, 5-10 by 2.5-6.3 cm, ovate or ovate-lanceolate, petiolate, petioles terete to 6 cm long, glabrous or puberulous when young; leaflets subsessile, ovate-elliptic or elliptic-lanceolate, oblique at base, shallowly crenate-serrate at margin, tapering at apex, membranous, pellucid-punctate, pale green. New foliage is glossy and pinkish-maroon in colour. Mature leaf emits a disagreeable odour when bruised.

Inflorescences axillary and terminal, racemose or corymbose, few-flowered, 4-5 cm long; peduncles densely puberulent; pedicels 2-4 mm long. Flowers come in March-May, are bisexual, borne in clusters of 4 to7 along young branch lets, each nearly 2 cm wide, sweet scented and greenish white. Calyx gamosepalous, pubescent, cupular, finely puberulent, caducous; lobes 4 or 5, 3-angled, light green. Petals 4-5, fleshy, sub-equal, recurved, oblong ovoid, blunt, thick, pale greenish outside, yellowish inside and dotted with oil glands. Androecium polyandrous, stamens are basifixed, numerous in 2 or 3 series, free or basally subconnate, dehiscing longitudinally, greenish yellow, unequal sometimes coherent in bundles. filaments subulate, long, glandular; anthers linear-oblong, Disc glabrous, greenish. Ovary ovoid, 4-5 mm long, faintly ridged, 10-loculed; ovules many, 2-seriate; style short, terminal; stigma capitates, oblong, longitudinally grooved [3,10].

Bael fruits come in June, are round woody berry, egg shaped with a beak near the attachment of the fruiting stalk [11]. Fruit is many seeded, oval or oblong, pyriform in shape, 5 to 20 cm in diameter, with a thin, hard, woody shell or a more or less soft rind, grey green until the fruit is fully ripe, when it turns yellowish rind with small dots on outer surface [3, 10, 12]. Rind about 1/8 inch thick and adherent to a light red pulp, in which are ten to fifteen cells, each containing several woolly seeds [13]. The Fresh pulp is extremely mucilaginous sweet and thick, a yellowish-orange to brown color, of sticky shreads, dried pulp hard and pale to dark red in colour, frequently breaks away from the rind during drying, leaving a thin layer attached to it, odour, faintly aromatic, taste, mucilaginous and slightly astringent. It takes about 11 months for the fruit to ripen on the tree and they can reach the size of a large grapefruit and some are even larger [13,14], seeds non-endospermous and surrounded by a mucilaginous mass [15], numerous, minute, embedded in the pulp, oblong, compressed, wooly with white cotton like hairs on their outer surface. Embryo with thick fleshy cotyledons. Fruit shell is so hard it must be cracked with a hammer [3,10,12,15].

3c. Microscopical Description (T.S.):

Leaf : Petiole is broad 'C' shaped in outline with a single layer of schizogenous cavity and a conspicuous broad. 'C' shaped vascular bundle in the centre. Lamina shows epidermis is single layered occasionally interrupted with sunken stomata on both surfaces and over- lined by a thick layer of cuticle. Interior to the epidermis is a many layered palisade tissue, which consists of closely, packed oval cell without much intercellular space. The chloroplasts are more abundant in the palisade cells and less in the spongy tissue. Both upper and lower epidermal layers bear stomata. Each stoma has two guard cells and two subsidiary cells and they correspond to rubiaceous type. The numerical values like vein- islet number, palisade ratio and stomata index are significantly diagnostic features of this species [15].

Stem bark: Presence of cork zone showing 5-8 stratification. It is stratified, tangentially elongated, lignified, with four to eight bands alternating with smaller cells and larger cells; secondary cortex wide, parenchymatous mixed with stone cells present in more number of groups in the phelloderm and also present in groups in the phloem fibers present in groups arranged in concentric rings secondary phloem consisting of fibres, sieve elements and crystal fibre, traversed by phloem rays; phloem fibres long, tapering, sharply pointed to blunt; fibre groups arranged in rings; phloem rays uni to triseriate, biseriate rays being more common [16].

Stem: presence of well developed periderm consisting of cork, phellogen and phelloderm, distinct patches of stone cells above the phloem region, several layers of cambium, conspicuous xylem with large vessels and uniseriate medullary rays and parenchymatous pith [17].

Root : Presence of outer zone of cork which gets peeled off consequent on secondary growth followed by phellogen and secondary cortex whose cells contain abundance of starch grains, interior to the cortex is the characteristic concentric patches of sclerenchyma, phloem is concentrically arranged, phloem cells alternating with narrow strip of sclerenchyma; medullary rays, distinct ring of cambium, wood consisting of large vessels, tracheids and fibers, uniseriate and biseriate medullary rays filled with starch grains, and pentarch primary xylem are also present [18].

4. Folk Uses of the Plant

Plants are used traditionally in healing of several diseases. Leaves, roots, fruits, seeds all are having great uses in curing of human ailments.

Leaves are used in relief of pain. They are also widely used in Abscess, back ache, abdominal disorders. Leave juice is used as laxative. Leaves are also in use as veterinary medicines. A leaf decoction is effective in relieving asthma [19].

Fruit of this plant is hopefully the most commonly used part both as medicines and food supplement. Traditional uses of the fruit against multiple illnesses related to intestinal system and gastric trouble. Fruits are used in dysentery, diarrhea, constipation, laxative, digestive etc. Particularly ripe fruits are used in chronic dysenteric condition and unripe fruits are used as an astringent in dysentery, stomach ache in diarrhea. Fresh juice is bitter and pungent, which lowers the blood sugar [20].

Root is used in intermittent fever and as fish poison, also used as a remedy for palpitation of heat and melancholia. Juice of the root bark with a little cumin in milk is valued as remedy for poverty of seminal fluid [21].

Decoction of bark has been found to be effective in curing malaria [19] and flower decoction is used as eye lotion [19].

5. Nutritional values

The bael has got nutritive properties throughout its whole plant. Besides secondary metabolites especially the fruits are a rich source of the carbohydrates and minerals [7] and traces of proteins and amino acids are also found [21]. In comparison to other parts of the plant, fruits bear highest nutritional values. Nutritional values of fruits [22] are presented in table 3.

Table 3: Nutritional values of fruits

Nutrients	Quantity (per 100gm)
Total carbohydrate	31.8 gm
Total protein	1.8 gm
Fat	0.3 gm
Fibre	2.9 gm
Vitamin B1	0.13 mg.
Vitamin B2	1.19 mg.
Vitamin B3	1.1 mg.
Vitamin C	60 mg.
Carotene	55 µg.
Iron (Fe)	0.6 mg
Calcium (Ca)	85 mg.
Phosphorus (P)	50 mg.
Potassium (K)	600 mg.

6. Economical Importance:

Around the globe there are few medicinally important plants which have also been found to be tree of economical importance due to its multifaceted uses besides its nutritional and therapeutic values. *A. marmelos* is such a plant whose whole aerial part is exploited in different ways. The essential oil obtained from the leaves, twigs and fruit rinds is limonene rich and hence used in perfumery works especially in manufacturing of hair oil [7]. Water decoction of leaves is used in bathe. Gum and resins of unripe fruit are used as adhesive in domestic purpose and also in jewellery works [23]. Yellow pigments obtained from fruit rind are ardently used as dye for silk fabrics. The wood (stem) is used for carving & small scale turnery and in manufacturing of some household goods [2]. Above all the uses of the fruit pulp as all day food [22] is highly envisaged in Indian subcontinent. Lastly, it is to be mentioned that the leaves being mythologically important, are used in religious practices which opens a venue of income generation for small vendors in cities of India.

7. Chemical Constituents Isolated from Different Parts of the Plant

A. marmelos has been reported to contain a numerous number of secondary metabolites [19] mainly alkaloids, coumarinoids, terpenoids, steroids, flavonoids etc. Several parts of the tree such as leaf, bark, fruit, seed and root bear a diversified class of compounds. Fruit and leaves in different stage of development show the content variations quantitatively. Major phytoconstiuents [24] isolated from the plant parts are Aegeline, Aegelenine, alloimperatorin, Anhydromarmeline, Dictamine, Fragarine, Halfordinol, Imperatorin, Luvangetin, Marmeline, Marmelonine, Marmenol, Marmesin, Marmesinin, Marmin, Psoralen, Rutaretin, Rutin, Sahidine, Scoparone, Scopoletin, Skimmianine, Umbelliferone. The comprehensive lists of the phytoconstiuents isolated from the different plant parts are mentioned below under subheading of the parts of the plant. It has been observed that there are numbers of phytoconstituents which are common to the different parts of the plant. At the end of the list the structures and analytical data including the NMR and Mass spectra of selected major phytoconstituents have been considered to the present study.

7a. Leaf: Green leaves of the plant when extracted with different solvents like ethanol, methanol, ethyl acetate etc. it bears a number of isolates [6, 7, 21, 25-29]. Steam distillation of the matured dried leaves yields a huge numbers of essential oils or triterpenoids [7,26,28]. Presence of some sesquiterpenoids like valencic acid [28] has also been reported. Beside those a few common aromatic constituents are also reported. Quantitative presences of different chemicals have also been studied for different stages of growth of leaves [27]. Another comparative study [6] of proximate analysis of wild and cultivated leaves and it has been found that wild verities are superior to cultivated one. Phytoconstituents isolated from leaves are mentioned in table 4, chemical composition of essential oil isolated from leaves are mentioned in table 5. A comparative proximate analysis chart of leaves at different stages of growth are given in table 6, a proximate analysis is reported for wild and cultivated leaves in table 7.

Table 4: Phytoconstituents isolated from leaf

Isolated Compounds from Leaves	Class of Compound
Aegelenine, Aegeline, Anhydromarmeline, Anthocyanins, N-2-(4-(3, 3,-dimethylallyloxy) phenyl) ethyl cinnamide, N-2-ethoxy-2-(4-methoxy phenyl) ethyl cinnamide, N-2-hydroxy-2-(4- hyderoxyphenyl) ethyl cinnamide, N-2-hydroxy-2-[4-(3',3' dimethylallyloxy) phenyl] ethylcinnamide or marmeline, N-2-methoxy-2-(4(3, 3-dimethylallylo) phenyl) ethylcinnamide, N-2-methoxy-2-(4-methoxyphenyl)–ethylcinnamide, O-halfordinol, Shahidine.	Alkaloid
Imperatorin, Marmelide, Marmelosin, Marmenol, Marmesin, Rutaretin, trans-coumarinoidoyltyramine.	Coumarinoid
Flavan-3-Ol, Flavonoid glycosides, Rutin,	Flavonoid
O-3,3-(dimethylallyl)halfordinol, α-sitosterol, β-sitosterol, γ-sitosterol,	Steroid
Skimmianine	Tannin

Table 5: Chemical composition of essential oil isolated from leaf of *A. marmelos*

(2E,6E)-Farnesal, (2Z,6Z)-Farnesol, Italicene ether, Limonene, (3Z)-Hexanyl butanoate, Linalool, (3Z)-Hexenol, Lupeol, (3Z)-Hexenyl benzoate, Methyl N-methylanthranilate, (3Z)-Hexenyl hexanoate, Methyl perillate, (E)-Caryophyllene, Myrcene, (E)-Nerolidol, Neral, (E)-Phytol, p-Anisaldehyde, (E)-β-Farnesene, p-cymene, (E)-β-Ocimene, p-Menth-1-en-3,5-diol, (E,E)-α-Farnesene, Sabinene, (Z)-Jasmone, Shyobunol, (Z)-β-Ocimene, trans-Cadina-1(6),4-diene, 1-epi-Cubenol, trans-Cadina-1,4-diene 3-Methyl-2-butenal, trans-Carveol, 4-methoxy benzoic acid, trans-Cinnamic acid, 7-epi-Sesquithujene, trans-Limonene oxide, Aegelinoside A & B, trans-Linalool oxide, Allocimene, trans-Murrola-4(14),5-diene, ar-Curcumene, trans-p-Mentha-2,8-dien-1-ol, Benzaldehyde, trans-Sesquisabinene hydrate, Betulinic acid, Valencic acid, Caryophylla-4(12),8(13)-dien-5-ol, α-amyrin, β-amyrin, Caryophyllene oxide, α-Cardinol, Cineol, α-Cedrene, cis-Limonene oxide, α-Copaene, cis-Linalool oxide, α-Cubebene, cis-Piperitol, α-Farnesene, cis-p-Mentha-2,8-dien-1-ol, α-Humelene, cis-Sesquisabinene hydrate, α-Muurolol, Citral, α-phellandrene, Citronellal, α-Pinene, Cubebol, α-Terpineol, Elemol, α-Zingiberene, epi-Cubebal,

β-Elemene, epi-Cubebol, β-Eudesmol, epi-α-Bisabolol, β-Funebrene, epi-β-Bisabolol, γ-Curcumene, Eremoligenol, γ-Elemene, Geranial, γ-Isogeraniol, Geraniol, γ-Terpinene, Germacra-4(15),5,10(14)-trien-1-α-ol, δ-Cadinene, Germacrene B, δ-Elemene, Germacrene D-4-ol,τ-Murolol

Table 6: Quantitative estimation of contents of leaves at different stages of growth

Analysis	Infant leaves	Matured leaves	Ripen Leaves
Moisture	37.80 %,	40.01 %	32.50 %
Ash	0.012 %	0.82 %	0.75 %
pH	6.3	6.0	6.15
Sugar (total)	0.90%	1.90%	1.70%
Sugar (reducing)	0.30%	0.90%	0.75%
Sugar (non reducing)	0.57%	0.95%	0.90%
Starch	0.80%	2.50%	2.00%
Fibre crude	8.10%	11.00%	9.50%
Vitamin C	3.50%	7.10%	6.00%
Phenolics (total)	1.90%	5.01%	3.99%
Sodium	2.50%	7.00%	6.50%
Potassium	1.52%	5.00%	3.99%
Calcium	0.00%	0.25%	0.21%
Phosphorous	3.50%	7.82%	7.11%
Magnesium	0.79%	2.17%	0.46%
Iron	3.32%	1.98%	3.23%
Zinc	1.50%	0.78%	1.50%
Copper	1.29%	0.01%	0.46%
Lead	0.56%	0.04%	0.67%
nickel	0.00%	0.86%	0.02%
cobalt	0.19%	0.45%	0.57%

Table 7: Comparative proximate analysis data of wild and cultivated leaves

Contents	Wild	Cultivated
Moisture (%)	54.0	52.4
Crude Protein (%)	7.6	2.22
Crude Fat (%)	8.18	12.7
Crude Fiber (%)	30.14	25.1
Ash (%)	6.5	6.0
Carbohydrate (%)	10.3	5.4
Zinc (ppm)	0.067	0.026
Chromium (ppm)	49	38
Iron (ppm)	181	169

7b. Fruit: Both ripened and unripe fruits are the rich source of secondary metabolites [24, 25, 28, 30,31]. The stages of developments of the fruits are indicated by the quantitative presence of the several phytoconstiuents. Quantitative contents of carbohydrates like mono and disaccharides have been found to be variable with growth of the fruits. In table 8 phytoconstituents isolated from fruit are reported.

7c. Seed: Seeds of the ripened fruits are the rich source of essential oils and some fatty acids. Some intermediate compounds have also been reported [6,21] from the study of the seeds. Table 9 representing the constituents isolated from seeds.

7d. Bark: The distribution of the limited class of secondary metabolites [6, 28, 31] has also been observed in the stem bark. The phytoconstituents isolated from bark are represented in table 10.

7e. Root: Roots of the plant have also been found to bear coumarinoids, alkaloids and oils and fatty acids. Phytoconstituents isolated [21, 28] from root are represented in table 11.

Table 8: Phytoconstituents isolated from fruit

Compounds	Class of Compounds
Aegeline, Anhydromarmelin, Dictamine, Fragarine, Luvangetin, Marmelin, Marmesinin, O-methylhalfordinine, Pectin,Skimmianine	Alkaloid
Arabinose, Galactose, Rhamnose, Uronic acid	Carbohydrate
Alloimperatorin, Imperatorin, Marmelide, Marmelosin, Marmesin, Marmin, Marmelonine, Psoralen, Scoparone, Scopoletin, Scopolone, Umbelliferone, Xanthotoxol, Xanthoxin.	Coumarinoid
Chlorogenic acid-136.8ug/g, Ellagic acid-248.5ug/g, Ferulic acid-98.3ug/g, Gallic acid-873.6ug/g, Procatechuic acid-47.9ug/g, Quercetin-56.9ug/g , Rutaretin.	Polyphenols
Hexanal, Isoamyl acetate, Limonene, Methyl ether, β-phellandrene, p-cymene, Acetoin, (E)-2-octenal, (E,E)-2,4-heptadienal, Dehydro-p-cymene, Linalool oxide, 3,5-octadiene-2-one, α-cubebene, trans-p-mentha-2,8-dienol, Citronellal, β-cubebene, β-caryophyllene, Hexadecane, Pulegone, α-humelene, Varbenone, Carvone, Carvyl acetate, Dihydro- β-lonone, (E)-6,10-dimethyl-5,9-undecadien-2-one, β-lonone, Caryophyllene oxide, Humelene oxide, Hexadecanoic acid, Auraptene, Betulinic acid, α-amyrin, β-amyrin.	Triterpenoid

Table 9: Phytoconstituents isolated from seed

Compounds	Qty.
Essential oil	34.40%
Limonene	-
Phellandrene	-
Cineol	-
Citronellal	-
Citral	-
p-cymene	-
Cuminaldehyde	-
Fatty acid contents	
Palmitic	16.6%
Stearic	8.8%
Oleic	30.5%
Linoleic	36.0%
Linolenic	8.1%
Ricinoleic	12.5%

Table 10: Phytoconstituents isolated from bark

Compounds	Class of Compound
Marmin	Coumarinoid
Marmesin (present also in heart wood)	
α-amyrin, β-amyrin, Fagarine	Triterpenoid

Table 11: Phytoconstituents isolated from root

Compound	Class of Compound
Decursinol, Lupeol,	Oil
Dimethoxy coumarin, Marmesin, Marmin	Coumarinoid
Haplopine, Lembamide, Skimmilamine, Skimmin	Alkaloid
α-amyrin, β-amyrin	Triterpenoid

8. Analytical data of selected major Phytoconstiuents.

A list of selected major phytoconstituents whose analytical data, predicted NMR and Mass data [32-51] are presented here in table 12.

Table 12: List of major phytoconstituents

No. in figure. 1	Name of the compound	NMR Reference
1.	Aegelenine	32
2.	Aegeline	33
3.	Alloimperatorin	34
4.	Anhydromarmelin	35
5.	Dictamine	36
6.	Fragarine	37
7.	Halfordinol	38
8.	Imperatorin	39
9.	Luvangetin	40
10.	Marmeline	34
11.	Marmelonine	41
12.	Marmenol	42
13.	Marmesin	37
14.	Marmesinin	43
15.	Marmin	44
16.	Psoralen	45
17.	Rutaretin	46
18.	Rutin	47
19.	Sahidine	48
20.	Scoparone	49
21.	Scopoletin	50
22.	Skimmianine	51
23.	Umbelliferone	37

Table 13: Pharmacological and Biological Activities

Sl. No.	Activities	Extract (possible bioactive compound)	References
1.	Analgesic	Methanolic extract of leaves	53
2.	Antibacterial	Methanolic extract of fruit pulp	54, 22
3.	Anticancer	Leaf extract (Lupeol), Fruit extract (Marmelin)	55, 56

4.	Anticonvulsant	Alcoholic extract of leaves & fruits	57
5.	Antidiarrhoeal	Water extract of unripe fruit (tannins and mucealage substances)	58
6.	Antifertility	Methanolic extract of bark, Ethanolic extract of leaves	59, 60
7.	Antifilarial	Methanolic extract of leaves (coumarinoids)	61
8.	Antifungal	Ethanolic extract of seeds ((1-methyl-2-(3′- methyl-but-2′-enyloxy)- anthraquinone, imperatorin, plumbagin)	62, 63
9.	Antigenotoxicity	Aq. extract of fruits, Methanolic extract of Leaves (Polyphenols)	64, 65, 66
10.	Antihyperglycemic	Aq. extract of seeds (Aegeline)	67, 68, 69
11.	Antiinflammatory	Leaves extract	70
12.	Antimicrobial	Hydrodistillation (essential oils)	71
13.	Antioxidant	Leaf and fruit extract (Flavonoids, Tannins, phlobatannins)	72
14.	Antiproliferative	Hydralcoholic extract of leaves (Skimmianine)	73
15.	Antipyretic	Ethanolic extract of leaves	74
16.	Chemopreventive	Fruit extract (Lupeol, Rutin)	75
17.	Contractile activity	Alcoholic extract of leaves	76
18.	Diuretic	Ethanolic extract of fruit pulp	77
19.	Gastrointestinal	Aq. extract of fruits (marmelosin), Seed extract (luvangetin)	78, 52
20.	Hepatoprotective	Methanolic extract of leaves, Ethanolic and aq. extract of fruit pulp, Aq. extract of seeds	79, 80, 81
21.	Hypoglycemic	The water extract of fruit	68
22.	Immunomodulatory	Methanolic extract of fruit	82
23.	Insecticidal	Hydrodistillation of leaves (essential oils)	83
24.	Radioprotective	Hydroalcoholic extract of leaves	84
25.	Ulcer Healing	Methanolic and Aq. extract of seeds (marmin, quercetin)	85

Figure 1: Leaf (trifoliate) of Bael (Aegle marmelos)

Figure 2: Flower of Bael (Aegle marmelos)

Figure 3: Fruit of Bael (Aegle marmelos)

Figure 4: Stem bark of Bael (Aegle marmelos)

Figure 5: The structures of phytoconstituents 1-23

1. Aegelenine:

IUPAC Name: 4,8-dimethoxyfuro[2,3-b] quinoline

Chemical formula: $C_{13}H_{11}NO_3$. Molecular Weight: 229.23.

MS (EI, 70eV): *m/z* (%)= 229.07(100), 230.08(14.3), 231.08(1.6).

Elemental analysis: C, 68.11; H, 4.84; N, 6.11; O, 20.94.

^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 3.83 (6H, s, - OCH_3), 7.42 (1H, d, *J* = 7.5 Hz,-CH(Ar)), 7.54 (1H,d, *J* = 7.5, 1.5 Hz, -CH(Ar)), 7.73 (1H, t, *J* = 7.5, 7.5 Hz, -CH(Ar)), 7.98 (1H, d, *J* = 7.5, 1.5 Hz, -CH(Ar)), 8.13 (1H, d, *J* = 7.5 Hz, -CH (Ar)).
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 55.8, 59.3, 104.8, 106.4, 107.4, 108.1, 125.9, 139.4, 142.5, 155.9, 157.0, 163.1.

2. Aegeline:
IUPAC Name: N-(2-hydroxy-2-(4-methoxyphenyl)cinnamide.
Chemical formula: $C_{18}H_{19}NO_3$. Molecular Weight: 297.35.
MS (EI, 70eV): *m/z* (%)= 297.14(100), 298.14(19.8), 299.14(2.5).
Elemental analysis: C, 72.71; H, 6.44; N, 4.71; O, 16.14.
^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 3.31 (1H, dd, -CH_2), 3.56 (1H, dd, -CH_2), 3.65 (1H, s, -OH), 3.83 (3H, s, -OMe), 5.26 (1H, t, *J* = 7.0 Hz, CH (sp^3)), 6.46 (1H, d, *J* = 15.1 Hz, =CH), 6.92 (2H, m, *J* = 7.5, 1.5 Hz, CH(Ar)), 7.25- 7.60(8H, m –CH (Ar)), 8.03 (1H, s, -NH).
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 47.6, 55.8, 72.2, 114.5, 120.2, 127.0, 127.0, 127.9, 128.5, 128.5, 128.6, 128.6, 130.0, 135.2, 141.7, 159.5, 166.8.

3. Alloimperatorin:
IUPAC Name: 9-hydroxy-4-(3-methylbut-2-en-1-yl)-7H-furo[3,2-g]chromen-7-one.
Chemical formula: $C_{16}H_{14}O_4$. Molecular Weight: 270.28.
MS (EI, 70eV): *m/z* (%)= 270.09(100), 271.09(17.5), 272.10(1.5).
Elemental analysis: C, 71.10; H, 5.22; O, 23.68.
^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 1.70 (3H, s, -CH_3), 1.82 (3H, s, -CH_3), 3.21 (2H, d, *J* = 6.2 Hz, -CH_2), 5.35 (1H, s, -OH), 5.75 (1H, t, *J* = 6.2, -1.0, -1.0 Hz, =CH), 6.25 (1H, d, *J* = 10.2 Hz, =CH), 6.66 (1H, d, *J* = 7.5 Hz, =CH(furan ring)), 7.52 (1H, d, *J* = 7.5 Hz, =CH(furan ring)), 7.97 (1H, d, *J* = 10.9 Hz, =CH).
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 18.6, 24.6, 30.1, 105.9, 113.4, 114.0, 121.5, 123.1, 127.1, 127.2, 1311.8, 141.0, 144.2, 146.0, 147.2, 160.8.

4. Anhydromarmelin:
IUPAC Name: N-((E)-4-((3-methylbut-2-en-1-yl)oxy)styryl)cinnamide
(2R,3R)-2-(3,4,5-trihydroxyphenyl)chroman-3,5,7-triol.
Chemical formula: $C_{22}H_{23}NO_2$. Molecular Weight: 333.42.
MS (EI, 70eV): *m/z* (%)= 333.17(100), 334.18(24.1), 335.18(3.2).
Elemental analysis: C, 79.25; H, 6.95; N, 4.20; O, 9.60.
^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 1.70 (3H, s, -CH_3), 1.82 (3H, s, -CH_3), 4.68(2H, d, *J* =6.2 Hz, -CH_2), 5.39 (1H, t, *J* =6.2, -1.0, -1.0 Hz, =CH), 6.06 (1H, d, *J* = 15.1 Hz, =CH), 6.89 (1H, d, *J* = 15.1 Hz, =CH), 6.98 (2H, d, *J* = 7.5, 7.5, 1.5, 1.5 Hz, m –CH (Ar)), 7.33-7.40 (4H, m), 7.60 (4H, d, *J* = 7.5, 1.5 Hz, m –CH (Ar)), 7.69(1H, d, *J* = 15.1 Hz, =CH), 8.0 (1H, s, -NH)
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 18.6, 24.6, 64.9, 109.5, 112.6, 114.2, 114.2, 118.9, 119.6, 126.3, 126.3, 127.9, 128.5, 128.5, 128.6, 128.6, 128.7, 135.2, 138.4, 141.7,157.3,165.4.

5. Dictamine:
IUPAC Name: 4-methoxyfuro[2,3-b]quinoline(2R,3R)-2-(3,4,5-trihydroxyphenyl)chroman-3,5,7-triol.
Chemical formula: $C_{12}H_9NO_2$. Molecular Weight: 199.21.
MS (EI, 70eV): *m/z* (%)= 199.06(100), 200.07(13.2), 201.07(1.2).
Elemental analysis: C, 72.35; H, 4.55; N, 7.03; O, 16.06.

^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 3.83 (3H, s, -OMe), 7.42 (1H, d, *J* =7.5 Hz, -CH (Ar)), 7.63 (1H, t, *J* =7.5, 7.5, 1.5 Hz, -CH (Ar)), 7.82 (1H, t, *J* =7.5, 7.5, 1.5 Hz, -CH (Ar)), 7.97 (1H, d, *J* =7.5, 1.5 Hz, -CH(Ar)), 8.13(1H, d, *J* =7.5 Hz, -CH (Ar)), 8.36 (1H, d, *J* =7.5, 1.5 Hz, -CH (Ar)).
^{13}C NMR (125 MHz, $CDCl_3$, ppm): δ 59.3, 104.3, 104.8, 105.0, 122.2, 126.1, 128.2, 130.2, 142.5, 145.3, 157.7, 164.0.

6. Fragarine:
IUPAC Name: (6,8-dihydro-[1,3]dioxolo[4,5-e]isobenzofuran-6-yl)(6-vintlbenzo[d][1,3]dioxolo-5-yl)methanol
Chemical formula: $C_{19}H_{16}O_6$. Molecular Weight: 340.33.
MS (EI, 70eV): *m/z* (%)= 340.09(100), 341.10(21.0), 342.10(3.3).
Elemental analysis: C, 67.05; H, 4.74; O, 28.21.
^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 3.65(1H, s, -OH), 4.58-4.59(2H, m), 4.68 (1H, d, $-CH_2$), 5.21 (1H, d, *J* = 7.0 Hz, -CH (sp^3)), 5.34 (1H, dd, *J* = 10.0, 2.1 Hz, =CH), 5.44 (1H, dd, *J* = 16.8, 2.1 Hz, =CH), 6.07 (4H, s, CH_2), 6.74 (2H, s, *J* = 7.5, 7.5 Hz, -CH(Ar)), 6.90 (1H, m, *J* = 16.8, 10.0, Hz, =CH), 6.98 (1H, s,-CH(Ar)), 7.00(1H, s, -CH(Ar)).
^{13}C NMR (125 MHz, $CDCl_3$, ppm): δ 65.9, 75.7, 90.1, 101.2, 101.5, 109.3, 111.4, 112.1, 114.3, 120.6, 127.6, 133.3, 133.5, 134.5, 135.4, 147.6, 148.2, 148.5, 148.9.

7. Halfordinol:
IUPAC Name: 4-(2-(pyridine-3-yl)oxazol-5-yl)phenol
Chemical formula: $C_{14}H_{10}N_2O_2$. Molecular Weight: 238.24.
MS (EI, 70eV): *m/z* (%)= 238.07(100), 239.08(15.3), 240.08(1.5).
Elemental analysis: C, 70.58; H, 4.23; N, 11.76; O, 13.43.
^{1}H NMR (500 MHz, $CDCl_3$, ppm), s**:** δ 1.70 (3H, $-CH_3$), 1.82 (3H, s, $-CH_3$), 4.68 (2H, d, *J* = 6.2 Hz, $-CH_2$), 5.39 (1H, t, *J* = 6.2, -1.0, -1.0 =CH), 7.09 (3H, m, *J* = 7.5, 1.5 Hz, -CH(Ar)), 7.57 (1H, t, *J* = 7.5, 7.5 Hz, -CH(Ar)), 7.66 (2H, d, *J* = 7.5, 1.5 Hz,-CH(Ar)) , 8.42 (1H, m, *J* = 7.5, 7.5, 1.5 Hz, -CH(Ar)), 8.70 (1H, d, *J* = 7.5, 1.5, 0.4 Hz, -CH(Ar)), 9.24 (1H, s, *J* = 1.5, 0.4 Hz, -CH(Ar)).
^{13}C NMR (125 MHz, $CDCl_3$, ppm): δ 18.6, 24.6, 64.9, 114.8, 114.8, 119.6, 120.5, 122.6, 124.0, 124.4, 127.3, 127.3, 134.0, 138.4, 147.9, 149.8, 152.7, 158.1, 159.3.

8. Imperatorin/ Marmelide/Marmelosin:
IUPAC Name: 9-((3-methylbut-2-en-1-yl)oxy)-7H-furo[3,2-g]chromen-7-one.
Chemical formula: $C_{16}H_{14}O_4$. Molecular Weight: 270.28.
MS (EI, 70eV): *m/z* (%)= 270.09(100), 271.09(17.5), 272.10(1.5).
Elemental analysis: C, 71.10; H, 5.22; O, 23.68.
^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 1.70 (3H, $-CH_3$), 1.82 (3H, s, $-CH_3$), 4.68 (2H, d, *J* = 6.2 Hz, $-CH_2$), 5.39 (1H, t, *J* = 6.2, -1.0, -1.0 =CH), 6.25 (1H, d, *J* = 10.9 Hz, -CH (Ar)), 6.66 (1H, d, *J* = 7.5, 1.5 Hz, -CH (furan ring)), 7.20 (1H, s, *J* = 1.5 Hz, -CH (Ar)), 7.52 (1H,d, *J* = 7.5, Hz, -CH (furan ring)), 7.97 (1H, d, *J* = 10.9 Hz, -CH (Ar)).
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 18.6, 24.6, 70.2, 105.9, 111.7, 113.4, 115.9, 119.6, 126.4, 131.6, 138.4, 142.7, 143.5, 146.0, 147.8, 160.8.

9. Luvangetin:
IUPAC Name: 10-methoxy-8,8-dimethylpyrano[3,2-g]chromen-2(8H)-one.
Chemical formula: $C_{15}H_{14}O_4$. Molecular Weight: 258.27.
MS (EI, 70eV): *m/z* (%)= 258.09(100), 259.09(16.4), 260.10(1.3).
Elemental analysis: C, 69.76; H, 5.46; O, 24.78.

^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 1.50 (6H, s, $-CH_3$), δ 3.83 (3H, s, -OMe), 5.97 (1H, d, *J* = 10.9 Hz, -CH (Ar)), 5.98 (1H, d, *J* = 10.9 Hz, -CH (Ar)), 6.88 (1H, d, *J* = 10.9 Hz, -CH (Ar)), 7.10 (1H, s, -CH (Ar)), 7.79(1H, d, *J* = 10.9 Hz, -CH (Ar)),
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 28.2, 28.2, 60.5, 85.5, 110.9, 113.4, 114.7, 121.7, 122.2, 128.3, 143.5, 144.5, 146.4, 146.8, 160.8.

10. Marmelin:
IUPAC Name: (Z)-N-(2-hydroxy-2-(4-((3-methylbut-2-en-1-yl)oxy)phenyl)ethyl)cinnamimidic acid
Chemical formula: $C_{22}H_{25}NO_3$. Molecular Weight: 351.44.
MS (EI, 70eV): *m/z* (%)= 351.88(100), 352.19(24.2), 353.19(3.4).
Elemental analysis: C, 75.19; H, 7.17; N, 3.99; O, 13.66.
^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 1.70 (3H, $-CH_3$), 1.82 (3H, s, $-CH_3$), 1.9 (1H, m, CH_2,), 2.0 (1H, s, -OH), 3.65 (1H, s, -OH), 4.5 (1H, t, *J* = 7.0 Hz, CH(sp^3)), 4.68 (2H, d, *J* = 6.2 Hz, CH_2), 5.39 (1H, t, *J* = 6.2, -1.0, -1.0 Hz, =CH), 5.67 (1H, d, *J* = 15.1 Hz, =CH, 6.79 (1H,d, *J* = 15.1 Hz, =CH), 6.96 (2H, d, *J* = 7.5, 1.5 Hz, CH(Ar), 7.23 (2H, d, *J* = 7.5, 1.5 Hz, CH(Ar)), 7.33-7.40 (3H, m, -CH(Ar)).
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 18.6, 24.6, 58.3, 64.9, 73.8, 115.0, 119.6, 119.7, 119.7, 127.0, 127.0, 127.9, 128.5, 128.5, 128.6, 128.6, 132.9, 135.2, 138.4, 140.4, 157.0, 158.9.

11. Marmelonine: (replaced sitosterol)
IUPAC Name: 3-hydroxy-3-methyl-3,3a-dihydro-2H-furo[2`, 3`:4, 5]furo[3,2-g]chromen-7(10bH)-one
Chemical formula: $C_{14}H_{12}O5$. Molecular Weight: 260.24.
MS (EI, 70eV): *m/z* (%)= 260.07(100), 261.07(15.5), 262.08(1.1), 262.07(1.0).
Elemental analysis: C, 64.61; H, 4.65; O, 30.74.
^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 1.29 (3H, s, $-CH_3$), 3.73 (1H, d, $-CH_2$ (SP^3)), 3.98 (1H, d, $-CH_2$ (SP^3)), 4.50 (1H, d, J=7.0Hz, -CH (SP^3)), 5.53 (1H, d, J=7.0 Hz, -CH(SP^3)), 6.25 (1H, d, J= 10.9 Hz, CH (Ar)), 6.90 (1H, s, -CH (Ar)), 7.59 (1H, s, -CH (Ar)), 7.97 (1H, d, J=10.9 Hz, -CH (Ar)).
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 20.9, 74.7,79.4, 87.7, 91.9, 97.3, 113.4, 113.5, 113.6.

12. Marmenol:
IUPAC Name: (E)-7-((3,7-dimethylocta-2,6-dien-1-yl)oxy)-2H-chromen-2-one
Chemical formula: $C_{19}H_{22}O_3$. Molecular Weight: 298.38.
MS (EI, 70eV): *m/z* (%)= 298.16(100), 299.16(20.9), 300.16(2.6).
Elemental analysis: C, 76.48; H, 7.43; O, 16.09.
^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 1.24 (6H, s, CH_3), 1.48 (2H, q, *J* = 7.1, 7.1 Hz, $-CH_2$), 1.48 (2H, q, *J* = 7.1, 7.1 Hz, $-CH_2$), 1.96 (2H, t, *J* = 7.1, -1.0, -1.0 Hz, $-CH_2$), 2.80 (1H, s, -OH), 3.30 (3H, s, -OMe), 3.52 (1H, t, *J* = 7.0, Hz, -CH(sp^3)), 3.58 (1H, s, -OH), 4.00 (1H, q, $-CH_2$), 4.25 (1H, q, $-CH_2$), 4.41 (1H, t, *J* = 7.0, -1.0, -1.0 Hz, $=CH_2$), 5.32 (1H, s, *J* = 2.1, -1.0 ,-1.0 Hz, $=CH_2$), 5.97 (1H, d, *J* = 10.9, Hz, -CH(Ar)), 6.95-6.97 (2H, m, CH(Ar)), 7.63 (1H, d, *J* = 7.5 Hz, -CH(Ar)), 7.79 (1H, d, *J* = 10.9 Hz, -CH(Ar)).
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 22.3, 22.3, 28.9, 30.3, 49.3, 72.4, 73.8, 76.3, 85.1, 104.1, 111.1, 111.8, 113.3, 113.4, 129.4, 143.5, 149.6, 156.5, 159.0, 160.8.

13. Marmesin:
IUPAC Name: (S)-2(2-hydroxypropan-2-yl)-2H-furo[3,2-g]chromen-7(3H)-one.
Chemical formula: $C_{14}H_{14}O_4$. Molecular Weight: 246.26.
MS (EI, 70eV): *m/z* (%) = 246.09(100), 247.09(15.3), 248.10(1.1).
Elemental analysis: C, 68.28; H, 5.73; O, 25.99.

^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 1.24 (6H, s, $-CH_3$), 3.00 (1H, q, $-CH_2$), 3.25 (1H, q, $-CH_2$), 3.65 (1H, s, -OH), 4.68 (1H, t, *J* = 7.0, Hz, -CH(sp^3)), 5.97 (1H, d, *J* = 10.9, Hz, -CH(Ar)), 6.92, (1H, s, -CH(Ar)), 7.52 (1H, s, -CH(Ar)), 7.79 (1H, d, *J* = 10.9 Hz, -CH(Ar)).
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 25.7, 25.7, 29.4, 73.0, 93.9, 113.4, 113.6, 124.6, 124.7, 143.5, 153.7, 160.5, 160.8.

14. Marmesinin:
IUPAC Name: (S0-2-(2-(((2S,3R,4S,5S,6R)-3,4,5-TRIHYDROXY-6-(hydroxymethyl)tetrahydro-2H-pyran-2-yl)oxy)propan-2-yl)-2H-furo[3,2-g]chromen-7(3H)-one.
Chemical formula: $C_{20}H_{24}O_9$. Molecular Weight: 408.40.
MS (EI, 70eV): *m/z* (%)= 408.14(100), 409.15(22.3), 410.15(4.2).
Elemental analysis: C, 58.82; H, 5.92; O, 35.26.
^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 1.24 (6H, s, $-CH_3$), 3.00 (1H, q, $-CH_2$), 3.25 (1H, q, $-CH_2$), 3.40-3.54 (3H, m), 3.58 (3H, s, -OH), 3.65 (1H, s, -OH), 3.73-3.79 (3H, m), 4.92 (1H, t, -CH (sp_3)), 5.03 (1H, d, *J* = 7.0 Hz, CH(sp^3)), 6.92, (1H, s, -CH(Ar)), 7.52 (1H, s, -CH(Ar)), 7.79 (1H, d, *J* = 10.9 Hz, -CH(Ar)).
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 22.9, 22.9, 29.7, 62.2, 71.5, 74.4, 76.8, 81.5, 87.1, 92.0,98.1, 105.3 113.4, 113.6, 124.6, 124.7, 143.5, 153.7, 160.5, 160.8.

15. Marmin:
IUPAC Name: (R,E)-7-((6,7-dihydroxy-3,7-dimethyloct-2-en-1-yl)oxy)-2H-chromen-2-one
Chemical formula: $C_{19}H_{24}O_5$. Molecular Weight: 332.39.
MS (EI, 70eV): *m/z* (%)= 332.16(100), 337.17(21.0), 334.17(3.1).
Elemental analysis: C, 68.66; H, 7.28; O, 24.07.
^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 1.24 (6H, s, $-CH_3$), 1.48 (2H, q, *J* = 7.1, 7.1 Hz, $-CH_2$), 1.82 (3H, s, CH_3) 1.96 (2H, t, *J* = 7.1, -1.0, -1.0 Hz, $-CH_2$), 3.28 (1H, t, *J* = 7.0 Hz, -CH (sp^3)), 3.58 (3H, s, -OH), 3.65 (1H, s, -OH), 4.68 (2H, d, *J* = 6.2 Hz, $-CH_2$), 5.39 (1H, s, *J* = 6.2, -1.0 ,-1.0 Hz, $=CH_2$), 5.97 (1H, d, *J* = 10.9, Hz, -CH(Ar)), 6.99-7.01 (2H, m, CH(Ar)), 7.61 (1H, d, *J* = 7.5 Hz, -CH(Ar)), 7.79 (1H, d, *J* = 10.9 Hz, -CH(Ar)).
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 16.3, 25.7, 25.7, 29.7, 35.9, 65.2, 75.2, 78.0, 104.0, 111.0, 112.5, 113.4, 118.4, 129.8, 141.9, 143.5, 156.9, 160.8, 161.3.

16. Psoralen:
IUPAC Name: 7H-furo[3,2-g]chromen-7-one
Chemical formula: $C_{11}H_6O_3$. Molecular Weight: 186.16.
MS (EI, 70eV): *m/z* (%)= 186.03(100), 187.04(12.1), 188.04(1.3).
Elemental analysis: C, 70.97; H, 3.25; O, 25.78.
^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 6.25 (1H, d, *J* = 10.9 Hz, -CH (Ar)), 6.66 (1H, d, *J* = 7.5, 1.5 Hz, -CH (furan ring)), 7.20 (1H, s, *J* = 1.5 Hz, -CH (Ar)), 7.52 (1H,d, *J* = 7.5 Hz, -CH (furan ring)), 7.63 (1H, s, *J* = 1.5 Hz, -CH (Ar)), 7.97 (1H, d, *J* = 10.9 Hz, -CH (Ar)).
^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 102.2, 105.9, 113.4, 114.9, 119.4, 125.4, 143.5, 146.0, 151.5, 156.1, 160.8.

17. Rutaretin:
IUPAC Name: 9-hydroxy-6-(2-hydroxypropan-2-yl)-2H-furo[3,2-g]chromen-7(3H)-one
Chemical formula: $C_{14}H_{14}O_5$. Molecular Weight: 262.26.
MS (EI, 70eV): *m/z* (%)= 262.08(100), 263.09(15.5), 264.09(2.1).
Elemental analysis: C, 64.12; H, 5.38; O, 30.50.
^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 1.28 (6H, s, $-CH_3$), 2.97 (2H, t, *J* = 7.1 Hz, $-CH_2$), 3.65 (1H, s, -OH), 2.97 (2H, t, *J* = 7.1 Hz, $-CH_2$), 3.65 (1H, s, -OH), 7.08 (1H, s, -CH(Ar)), 7.79 (1H, s, -CH(Ar)),

^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 28.3, 28.3, 30.2, 71.6, 74.2, 115.1, 116.8, 125.4, 135.6, 136.2, 140.0, 141.2, 146.9, 161.9.

18. Rutin:

IUPAC Name: 2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-(((2R,3S,4R,5R,6S)-3,4,5-trihydroxy-6-((((2S,3S,4S,5S,6R)-3,4,5-trihydroxy-6-methyltetrahydro-2H-pyran-2-yl)oxy)methyl)tetrahydro-2H-pyran-2-yl)oxy)-4H-chromen-4-one.

Chemical formula: $C_{27}H_{30}O_{16}$. Molecular Weight: 610.52.

MS (EI, 70eV): *m/z* (%)= 610.15(100), 611.16(30.2), 612.16(7.7), 613.16 (1.4)

Elemental analysis: C, 53.12; H, 4.95; O, 41.93.

^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ1.18 (3H, s, J=6.8 Hz, CH3), 3.40-3.73 (13H, m), 3.85 (1H, m, J=7.0, 6.8 Hz, CH(sp3)), 4.00 (1H, m, J= 7.0 Hz, CH(sp3)), 5.03 (1H, d, J=7.0 Hz, CH (sp3)), 5.35 (4H, s, -OH), 5.68 (1H, d, -CH (sp3)), 5.94 (1H, d, J=1.5 Hz, CH(Ar)), 6.25 (1H, d, J=1.5 Hz, CH (Ar)), 6.72 (1H, d, J=1.5 Hz, CH (Ar)), 6.93 (1H, d, J=7.5 Hz, CH (Ar)), 7.15 (1H, d, J=7.5, 1.5 Hz, CH(Ar)).

^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 17.0, 68.6, 71.8, 72.4, 73.7, 73.8, 74.2, 75.1, 76.9, 80.8, 94.0, 98.3, 104.5, 109.6, 112.0, 117.2, 121.8, 122.8, 135.1, 145.9, 146.5, 156.4, 158.8, 161.8, 166.4, 178.2.

19. Sahidine:

IUPAC Name: (R,E)-5-(4-methoxyphenyl)-2-styryl-4,5-dihydrooxazole.

Chemical formula: $C_{18}H_{17}NO_2$. Molecular Weight: 279.33.

MS (EI, 70eV): *m/z* (%)= 279.13(100), 280.13(19.7), 281.13(2.3).

Elemental analysis: C, 77.40; H, 6.13; N, 5.01; O, 11.46.

^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 3.83 (3H, s, -OMe), 3.88 (1H, m, CH_2), 4.13 (1H, m, CH_2), 4.5 (1H, t, *J* = 7.0 Hz, -CH(sp3)), 5.67 (1H, d, *J* = 15.1 Hz, =CH) , 6.79 (1H, d, *J* = 15.1 Hz, =CH), 6.92 (2H, d, *J* = 7.5, 1.5 Hz, -CH(Ar)), 7.25 (2H, d, *J* = 7.5, 1.5 Hz, -CH(Ar)), 7.33 (1H, m , -CH(Ar)), 7.40 (2H, m, -CH (Ar)), 7.60 (2H, d, *J* = 7.5, 1.5, 1.5 Hz, -CH(Ar)),

^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 55.8, 59.6, 72.3, 114.5, 115.0, 127.0, 127.0, 127.9, 128.5, 128.5, 128.6, 128.6, 129.8, 135.2, 140.4, 159.5, 164.0.

20. Scoparone:

IUPAC Name: 6,7-dimethoxy-2H-chromen-2-one.

Chemical formula: $C_{11}H_{10}O_4$. Molecular Weight: 206.19.

MS (EI, 70eV): *m/z* (%)= 206.06(100), 207.06(12.2), 208.06(1.5).

Elemental analysis: C, 64.07; H, 4.89; O, 31.04.

^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 3.83 (6H, s, -OMe), 6.25 (1H, d, *J* = 10.9 Hz, -CH (Ar)), 6.76 (1H, s, -CH(Ar)), 6.86 (1H, s, -CH(Ar)), 7.97 (1H, d, *J* = 10.9 Hz, -CH (Ar)).

^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 56.1, 99.9, 109.8, 111.5, 113.4, 143.4, 146.5, 149.2, 149.4, 160.8.

21. Scopoletin:

IUPAC Name:7-hydroxy-6-methoxy-2H-chromen-2-one.

Chemical formula: $C_{10}H_8O_4$. Molecular Weight: 192.17.

MS (EI, 70eV): *m/z* (%)= 192.04(100), 193.05(11.1), 194.05(1.4).

Elemental analysis: C, 62.50; H, 4.20; O, 33.30.

^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 3.83 (6H, s, -OMe),5.35 (1H, s, -OH) 6.25 (1H, d, *J* = 10.9 Hz, -CH (Ar)), 6.76 (1H, s, -CH(Ar)), 6.86 (1H, s, -CH(Ar)), 7.97 (1H, d, *J* = 10.9 Hz, -CH (Ar)).

^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 56.1, 102.7, 110.2, 111.8, 113.4, 143.5, 145.3, 145.9, 149.6, 160.8

22. Skimmianine:

IUPAC Name: 4,7,8-trimethoxyfuro[2,3-b]quinoline

Chemical formula: $C_{14}H_{13}NO_4$. Molecular Weight: 259.26.

MS (EI, 70eV): *m/z* (%)= 259.08(100), 260.09(15.4), 261.09(1.9).

Elemental analysis: C, 64.86; H, 5.05; N, 5.40; O, 24.68.

^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 3.83 (9H, s, -OMe), 7.19, (1H, d, *J* = 7.5, CH(Ar)), 7.42 (1H, d, *J* = m7.5 – CH (Ar)),8.11-8.13 (2H, m, -CH(Ar)).

^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 56.1, 59.3, 60.9, 102.1, 102.4, 104.8, 112.2, 115.8, 141.7, 141.9, 151.9, 156.7, 163.6.

23. Umbelliferone:

IUPAC Name:7-hydroxy-2H-chromen-2-one

Chemical formula: $C_9H_6O_3$. Molecular Weight: 162.14.

MS (EI, 70eV): *m/z* (%)= 162.03(100), 163.04(9.9), 164.04(1.1).

Elemental analysis: C, 66.67; H, 3.73; O, 29.60.

^{1}H NMR (500 MHz, $CDCl_3$, ppm) : δ 5.35 (1H, s, -OH), 6.25 (1H, d, *J* = 10.9 Hz, -CH (Ar)), 6.62 (1H, *J* = 1.5 HZ , -CH(Ar)), 6.76 (1H, d, *J* = 7.5, 1.5 Hz, -CH(Ar)), 7.57 (1H, d, *J* = 7.5, Hz, -CH(Ar)), 7.97 (1H, d, *J* = 10.9 Hz, -CH (Ar)).

^{13}C NMR (125 MHz, $CDCl_3$, ppm) : δ 102.5, 112.6, 112.8, 113.4, 130.2, 143.5, 157.3, 158.1, 160.8

9. Pharmacological and Biological activities of *Aegle marmelos*

The large number of active chemical constituents like alkaloids, steroids, coumarinoids, terpenoids, flavonoids and many other polyphenols are responsible for its multifaceted pharmacological and biological activities. Several studies have been performed to demonstrate its different activities. A comprehensive table (no. 13) represents the activities of the various extracts of different parts of the plant like fruits, seeds, bark, leaves and roots. It has been also observed[52] that isolated compound may show more than one kind of bioactivity, like skimmianine shows anticancer, diuretic, analgesic activities, similarly, aegeline shows cardioprotective and antihyperglycemic activity. The possible bioactive compound (s) present in corresponding extract, which may be responsible for the activities are mentioned in the parenthesis.

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