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JASMINUM GRANDIFLORUM LINN. – AN UPDATE REVIEW

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Keywords:

Jasminum grandiflorum Linn., Medicinal formulations, Pharmacological activity, Patents

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ABSTRACT: Plants form the basis of human and animal life. Plants are better choice for medicinal applications when compared to synthetic chemicals and the nature has provided various types of medicinal plants. *Jasminum grandiflorum* Linn. (family Oleaceae) is a night bloomy flowering plant and is an important source of methyl jasmonates which find utility in plant defense, fruit ripening, plant growth senescence and other physical processes. The aroma plant *Jasminum grandiflorum* Linn. is native to tropical and warm temperate regions and the plant is observed to have favorable properties which can be used to treat numerous ailments. The leaves of the plant find clinical use in Ayurveda for wound management. The flowers of the plant are used to adorn the women coiffure. In this article, an attempt has been made to provide an updated review on this plant with focus on the isolation and quantification of chemical constituents, medicinal potential and patents on the medicinal and cosmetic formulations comprising *Jasminum grandiflorum* Linn.

INTRODUCTION: *Jasminum grandiflorum* Linn. is a highly valuable medicinal plant, native to Asia, Kashmir, Afghanistan, and Persia, cultivated in India, wild in sub-tropical North-West Himalayas, Western Ghats, Nilgiris, France, Italy, China, Japan, India, Morocco and Egypt [1]. Numerous reports on its isolation, quantification, medicinal and cosmetic potential are available in the literature. A search of the available reports showed that more than a hundred patents have been granted until 2017 for formulations containing extracts of *Jasminum grandiflorum*.

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The medicinal formulations claim the cure of several organ-related disorders like stomach ailments, the stagnancy of the liver, gastric ulcer, neurasthenia, edema, sciatica, cardiac asthma, heat boils, nausea, constipation and removal of toxicity from the body. The cosmetic preparations comprise creams, emulsions and shampoo for hair and skincare, for the cure of dermatitis, for skin whitening and as antipruritic lotion, perfumes, hair dye and health care cigarettes. In view of the significant number of patents on products prepared from *Jasminum grandiflorum*, the authentic cultivation of this medicinal plant will fetch a high market value for the farmers and medicinal plant cultivators.

2. Botanical Description: *Jasminum grandiflorum* Linn. [2]

2.1. Taxonomy: *Jasminum grandiflorum* is a large scrambling suberect twining evergreen climbing

shrub and grows up to 10 to 15 m height. The leaves are opposite, imparipinnate compound, with three paired, foliates ending with a single leaf at the tip. The leaflets unit are elongate-lanceolate, acute, seven to eleven terminal leaflet somewhat massive than laterals, narrowing at the bottom, ovate-lanceolate, acute or acuminate, laterals ovate, terminal one larger than laterals and often partially united with surfaces with a ciliate margin. Flowers are terminal and axillary cymes, whorl lobes long and linear. They are very fragrant, 3.0-3.8 cm across, white tinged with the pink outside. The fruit is a blackberry, elliptic, globose berries when ripe [Taxanomic Serial No. 32967].

Plant Name	:	*Jasminum grandiflorum* Linn.
Subkingdom	:	Tracheobionta – Vascular plants
Super division	:	Spermatophyta – Seed plants
Division	:	Magnoliophyta – Flowering plants
Class	:	Magnoliopsida – Dicotyledons
Subclass	:	*Asteridae*
Order	:	Scrophulariales
Family	:	*Oleaceae* – Olive family
Genus	:	Jasminum
Species	:	Grandiflorum Linn.
Classical names	:	Jati, Sauanasyayani, Sumama, Chetika, Hridyagandha, Malati, Rajaputrika
Vernacular names	:	Hindi- Jati, Cameli Tamil- Jatimalli, Kotimalligai, Pitchi Sanskrit- Jati, Malati English- Spanish jasmine, common jasmine, Catalonian jasmine

3. Earlier Reviews on *Jasminum grandiflorum* Linn.: There are few earlier reviews on *Jasminum grandiflorum*. A review on the collection, techniques used for extraction of scent bearing molecules and their structures and a general review on the chemistry and legacy of methyl jasmonate and the synthetic hedione with parallel olfactory attributes [3] are available. The ethnobotany, phyto-chemistry and phytopharmacology of *Jasminum grandiflorum* has been reviewed briefly more recently [4, 5].

In the present study, all available literature on *Jasminum grandiflorum* from 1951 to 2018 is reviewed in the following sections.

1. Isolation of chemical constituents from *Jasminum grandiflorum* Linn.
2. Quantification of constituents of *Jasminum grandiflorum* Linn.
3. Medicinal potential of *Jasminum grandiflorum* Linn.
4. Patents on *Jasminum grandiflorum* Linn.

3.1. Isolation of Chemical Constituents: Investigations for the presence of chemical constituents of *Jasminum grandiflorum* were initiated as early as 1962 with the isolation and characterization of a fragrant lactone molecule from the oil and wax portion of *Jasminum grandiflorum*. A number of small molecules bestowing fragrance to the flowers were reported from its hexane extract. The plant is found to largely elaborate secoiridoids, triterpenoids, flavonoids and their glycosides. Long-chain aliphatic alcohols and esters, terpene molecules and other small molecules have also been identified.

3.1.1 Constituents of Leaves: From the dried leaves of *Jasminum grandiflorum*, two new secoiridoid glucosides, (2"R)- 2"- methoxy oleuropein [C2] and (2"S)-2"-methoxy oleuropein [C3] together with four known secoiridoid glucosides – oleuropein [C1], demethyl oleuropein [C4], ligstroside [C5] and oleoside di-methyl ester [C6], olivil [C7] and p-hydroxyphenethyl alcohol [C8] were isolated [6]. From the aerial parts of *Jasminum grandiflorum* the angiotensin converting enzyme inhibitor – oleacein [C9], 2- (3, 4-dihydroxyphenyl) ethanol [C10], isoquercitrin [C11] and ursolic acid [C12] were isolated [7]. Bioassay-guided fractionation of chloroform extract of leaves of *Jasminum grandiflorum* led to identification of two new antimicrobial compounds namely 3,5-dihydroxy-2,4-dimethyl-hexanoic acid 4-hydroxy-phenyl ester [C13] and 2-hydroxy-methyl-3-methyl-butyric acid phenyl ester [C14]. The study revealed the significance of the plant extract over individual isolated compounds [8].

An indole oxygenase enzyme was isolated from the leaves, which report also established that the enzyme indole oxygenase is a cuproflavoprotein [9]. A more recent report on the isolation of constituents from the methanolic leaf extract of *Jasminum grandiflorum* revealed the presence of glyceryl behenate [C15], glycerol cerotate [C16],

cerotyl O-β-D-diarabinoside [C17], stearyl-O-α-D-triglucoside [C18] and behenyl-O-α-D-triglucoside [C19]. The structures were characterized by spectral analysis and chemical reactions [10].

3.1.2. Constituents of Flower Buds: A number of hederagenin derivatives namely 3-O-α-L-rhamnopyranosyl-(1→2)-β- D-xylopyranosyl-hederagenin-28-O-β- D-galactopyranosyl- (1->6)- β- D- galactopyranosylester [C20], hederagenin-3-O-β-D-glucopyranosyl- (1- >3)-α-L-arabinopyranoside [C21], hederagenin-3-O-β-D- xylopyranosyl- (1->3)- α- L-rhamnopyranosyl-(1->2)- α- L- arabinopyranoside [C22], hederagenin-3-O-α-L-rhamnopyranosyl- (1->2)-α-L-arabinopyranoside [C23] and the oleanyl derivatives 2α, 3β,23-trihydroxyolean-12-en-28-oic acid-O-β-D- glucopyranosyl ester [C24] and 2α, 3β, 23-trihydroxyolean-12-en-28-oic acid O-α-L-rhamnopyranosyl- (1->4)- β- D- glucopyranosyl-(1>6)-β-D-glucopyranosyl ester [C25] have been characterized from flower buds [11].

Six flavonoid glycosides were isolated from the 70% alcoholic extracts of flower buds and their structures were identified as kaempferol-3,7-O-di-β-D-glucopyranoside [C26], kaempferol-3-O-(6"-O-acetyl)-β-D-glucopyranoside [C27], quercetin-3-O-sambubioside [C28], sulfurein [C29], butin-7-O-β-D-glucopyranoside [C30] and acacetin-7-O(α-D-apiofuranosyl) (1→6)- β- D- glucopyranoside [C31] [12]. Secoiridoid constituents characterized from flower buds are jasgranoside B, 6-O-methy-catalpol [C32], deacetyl asperulosidic acid [C33], aucubin [C34], 8-dehydroxy shanzhiside [C35] and loganin [C36] [13].

HPLC-DAD-ESI/MS analysis of the aqueous and hydromethanolic extract of flower buds led to the characterization of six phenolic compounds namely 5-dihydrocaffeoylquinic acid [C37], dihydro-methoxycaffeoylquinic acid [C38], 4-p-coumaroyl-quinic acid [C39], kaempferol- 3- O- (2, 6-di-rhamnosyl) glucoside [C40], quercetin-3-O-(2,6-di-rhamnosyl) glucoside [C41] and quercetin-3-O-(6-rhamnosyl) glucoside [C42]. The composition of these phenolics was also analyzed [14].

3.1.3. Constituents of Flowers: A fragrant lactone cis-5-(2-pentenyl) pentanolide [C43] from the oil and wax portion of the flowers of *Jasminum grandiflorum* was the first report of isolation of a compound from the flowers [15]. The small molecules identified from n-hexane extract of flowers are cis-3-hexenol,2-vinylpyridine, myrcene, benzyl alcohol, p-cresol, linalool, methyl benzoate, benzyl cyanide, benzyl acetate, α-terpineol, linalyl acetate, geraniol, indole, eugenol, methyl dihydrojasmonate, methyl anthranilate, cis-jasmone, methyl N-methylanthranilate, vanillin, nerolidol, cis-3-hexenyl benzoate, farnesol, benzyl benzoate, methyl palmitate, isophytol, geranyl-linalool, methyl linoleate and phytol [16].

Secoiridoid constituents of flowers include, 2"-epifraxamoside [C44], demethyl-2"-epifraxamoside [C45], jasminanhydride [C46] [17], 7-ketologanin [C47], oleoside-11-methyl ester [C48], 7-glucosyl-11-methyl oleoside [C49], ligstroside [C5], oleuropein [C1], 8-epi-kingiside [C50], 10-hydroxy-oleuropein [C51], 10-hydroxy- ligstroside [C52], oleoside-7, 11-dimethyl ester [C53], jasgranoside and jaspolyoside [18]. Flavonoid glycosides- kaempferol- 3-O-α-L-rhamnopyranosyl (1→3)- [α- L- rhamnopyranosyl (1→6)]- β- D-galactopyranoside [C54] and kaempferol-3-O-rutinoside [C55] [19] also constitute the molecules elaborated by the flowers of *Jasminum grandiflorum.*

3.1.4. Extraction Strategies and Composition of Oils: Methods of separation of oils from flowers of *J. grandiflorum* [20-22,] optimisation of the process and assessment of the composition are significant as the oils from part of many fragrant preparations. One of the earliest methods reported for isolation of oil from flowers of *J. grandiflorum* involved the vapourization of essential oil from flowers, adsorption of oil vapors on activated charcoal, and desorption of oil from the adsorber by the volatile solvent. The optimized conditions of the industrial process are documented [20].

Supercritical extraction of flowers produced an essential oil whose yield and quality was compared with that obtained from the industrial process involving direct hexane extraction. The optimization of experimental parameters gave an average 0.29% of concrete, which in turn yielded up to 42% of absolute. A comparison with the components of the direct hexane extractive indicated that the overall average composition of the supercritical extraction product was different

from that obtained by the industrial process with hexane. Benzyl benzoate and phytol were found to be abundant in the supercritical extraction product. The extractive showed variation in the organoleptic properties also. The odor profile was fairly modified although the fundamental aromatic characteristics of the jasmine concrete and absolute of both extractives were maintained [22].

Yet another comparative study of supercritical extraction and direct solvent extraction of flowers of *Jasminum grandiflorum* showed that the extractive from supercritical extraction was obtained as a relatively fat-free product in 0.26% yield and it was found to be enriched with terpenoids and benzenoids and reported to be an organoleptically accepted product. The major compounds of the extractive, benzyl acetate, (E,E)-α-farnesene [C56] and (Z)-3-hexenyl benzoate, along with indole, methyl anthranilate, (Z)-jasmone [C57], (Z)-methyl jasmonoate [C58] and (Z)-methyl epi-jasmonoate are reported to be responsible for the high diffusivity of the jasmine fragrance. These compounds have been obtained with improved recoveries in the supercritical extractive [23].

A study on the effect of duration of daylight and of the temperature on the growth, flowering and chemical composition of the oil of *J. grandiflorum* indicated that the composition varied with season, with the content of certain fragrant components (linalool, benzyl acetate, benzyl alcohol, cis-jasmone) increasing and those of heavier components (isophytol and its ester) decreasing with time. The composition of oil from the plants grown in phytotron conditions (under long duration) differed from that of commercial oils, with decrease in volatile components accompanied by an increase in heavy products occurring in controlled growth conditions [24]. Tissue culture studies were carried out to analyze the accumulation of essential oils of *J. grandiflorum* [25].

3.1.5. Yield Enhancement Strategies for Jasmine Concrete and Absolute: The yield of the concrete and absolute of the Indian *J. grandiflorum* flowers was compared with that of the same species from other countries, the seasonal yield being 0.31% of the weight of flowers as concrete and 53.6% of the concrete as absolute [26]. A remarkable increase in the yield and quality of the *jasmine* flower concrete was obtained by adopting the cold-press method [27].

3.1.6. Identification of Constituents by Gas Chromatographic Analysis:

TABLE 2: LISTS THE CHEMICAL CONSTITUENTS IDENTIFIED BY GAS CHROMATOGRAPHIC ANALYSIS

Anac Olcay, 1986[28]	Feng Huan Wei *et al.*, 2015[29]
1. Linalool	1. Benzyl acetate
2. Benzyl acetate	2. Nerolidol
3. Benzylalcohol	3. Cedrol
4. Nerolidol	4. Methyl myristate
5. p-cresol	5. 7-Tetradecene
6. Lactones	6. Benzyl benzoate
7. Indole	7. Neophytadiene
8. Benzoic acid	8. Perhydrofarnesyl Acetone
9. Methyl linoleate + vanilin	9. Phytol acetate
10. Benzyl benzoate	10. Nonadecane
11. Phytol (isomers)	11. Geranyl linalool
12. High paraffins	12. Methyl palmitate
	13. 3,7,11,15- tetramethyl -1-Hexadecen-3-ol
	14. Hexadecanoic acid
	15. 3,7,11-trimethyl-1,6,10-dodecatrien-3-ol
	16. 3,7,11,15-tetramethylhexadecanoic acid methyl ester
	17. 9,12,15-octadecatrienoic acid methyl ester
	18. Heneicosane
	19. Phytol
	20. Octadecanoic acid methyl ester
	21. 9,12,15-Octadecatrienoic acid
	22. Docosane
	23. Tricosane
	24. Tetracosane
	25. Pentacosane
	26. Hexacosane
	27. Heptacosane
	28. Octacosane
	29. Squalene
	30. Nonacosane

3.2. Quantification of Constituents: Gas chromatography (GC) and gas chromatography coupled mass spectrometry (GC-MS) methods have been adopted to analyze the constituents of the volatile oil. Samples of absolute from jasmine flowers of different origins were analyzed by capillary gas chromatography to reveal a higher concentration of benzyl acetate, p-cresol and indole in the Turkish samples and a lesser concentration of benzyl alcohol [28]. The major components benzyl acetate (38.5-42.3%) and phytol isomers (22.8-24.2%) were quantified from *Jasmine* concrete [27].

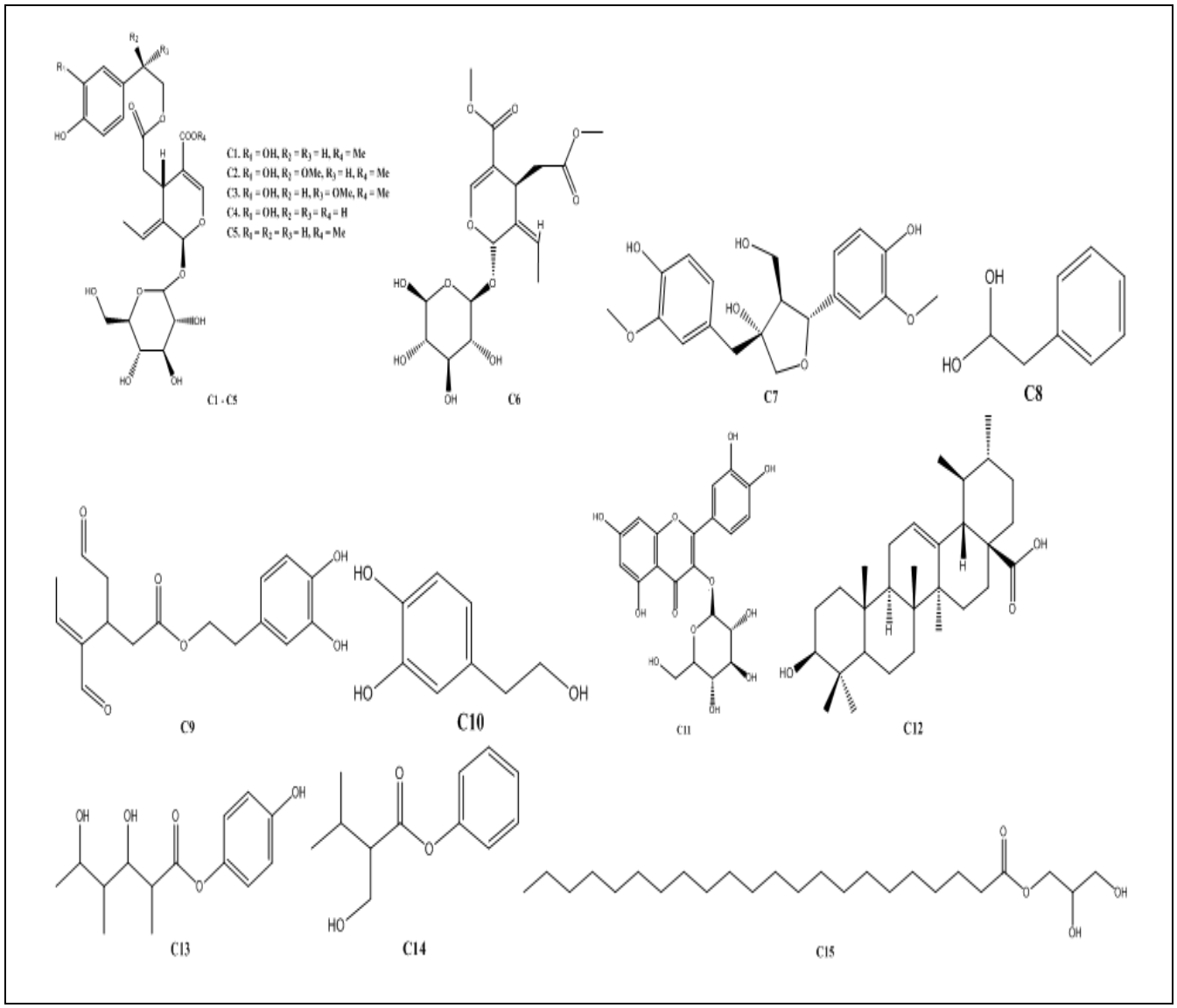
In an earlier study, the same authors have identified the above compounds by Gas Chromatographic analysis [28].

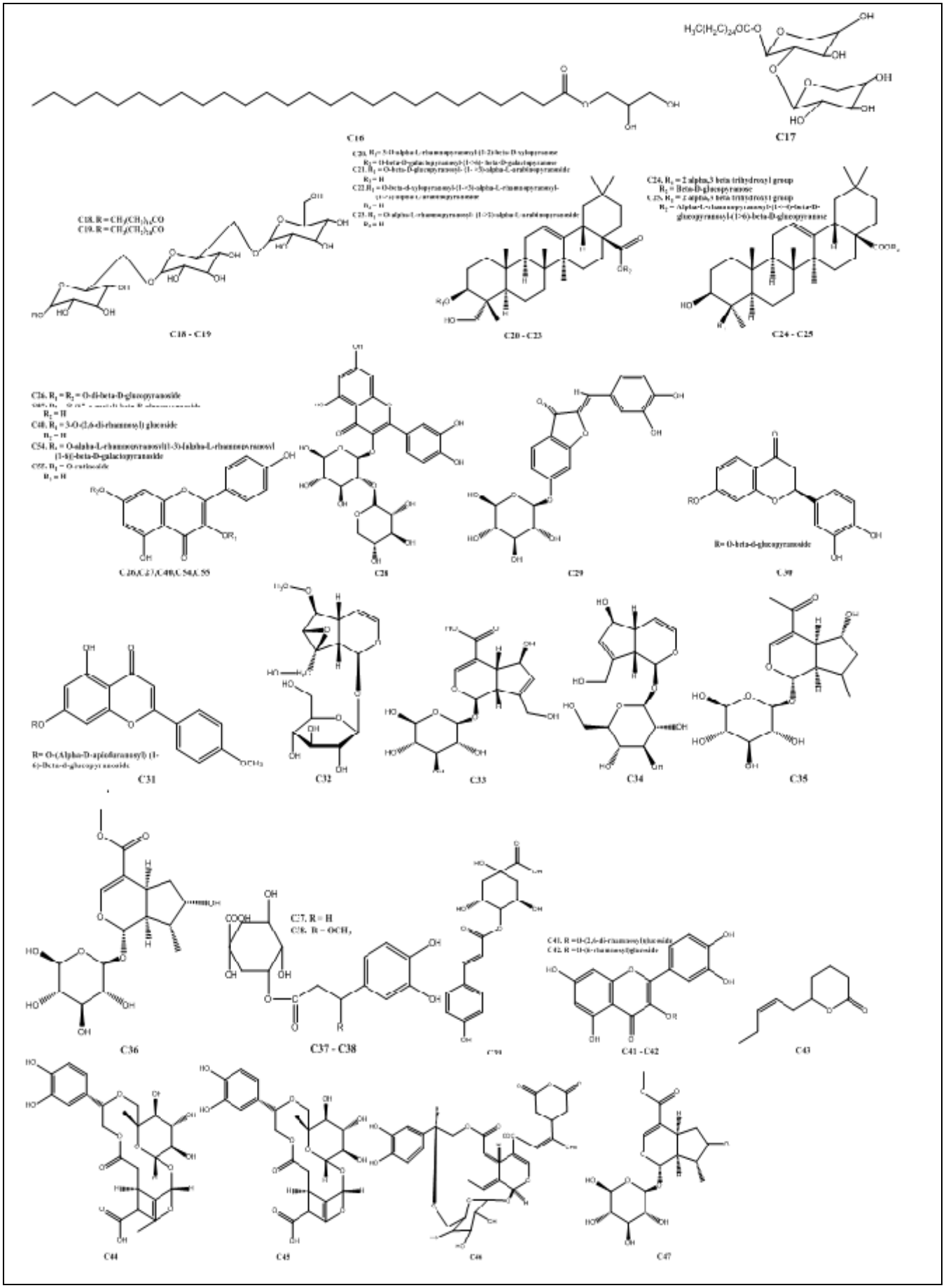
The major components of the absolute were identified and quantified as benzyl acetate (23.7%), benzyl benzoate (20.7%), phytol (10.9%), linalool (8.2%), isophytol (5.5%), geranyl linalool (3.0%), methyl linoleate (2.8%) and eugenol (2.5%) [30]. The major volatile components of the flowers were identified as phytol (25.77%), 3, 7, 11-trimethyl-dodeca -1, 6, 10-trien-3-ol (12.54%) and 3, 7, 11, 15-tetramethyl-1-hexadecen-3-ol (12.42%) [29].

The total flavonoid content was determined spectro-photometrically by the aluminum chloride colorimetric assay. The phenolic content was estimated at 7.8 mg/gallic acid equivalent and the flavonoid content as 1.23 mg/quercetin equivalent from 100 g of the leaves. The chromatographic profiling of different species was documented by TLC and HPLC [31].

The total iridoid glycoside content was determined by UV spectroscopy and oleuropein content by HPLC [32]. An HPLC-DAD-ESI/MS method was established for the chemical characterization of *Jasminum grandiflorum* to standardize the authentic species and six phenolic compounds were identified [14].

Chart 1: Chart 1 below represents the molecular structures of the chemical constituents isolated and characterized from *J. grandiflorum* Linn. The molecules identified by GC-MS analysis are separately classified as terpenoids, aromatic small molecules and aliphatic derivatives.




C16
C17
C18 - C19
C20 - C23
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C26,C47,C48,C 54,C 55
C28
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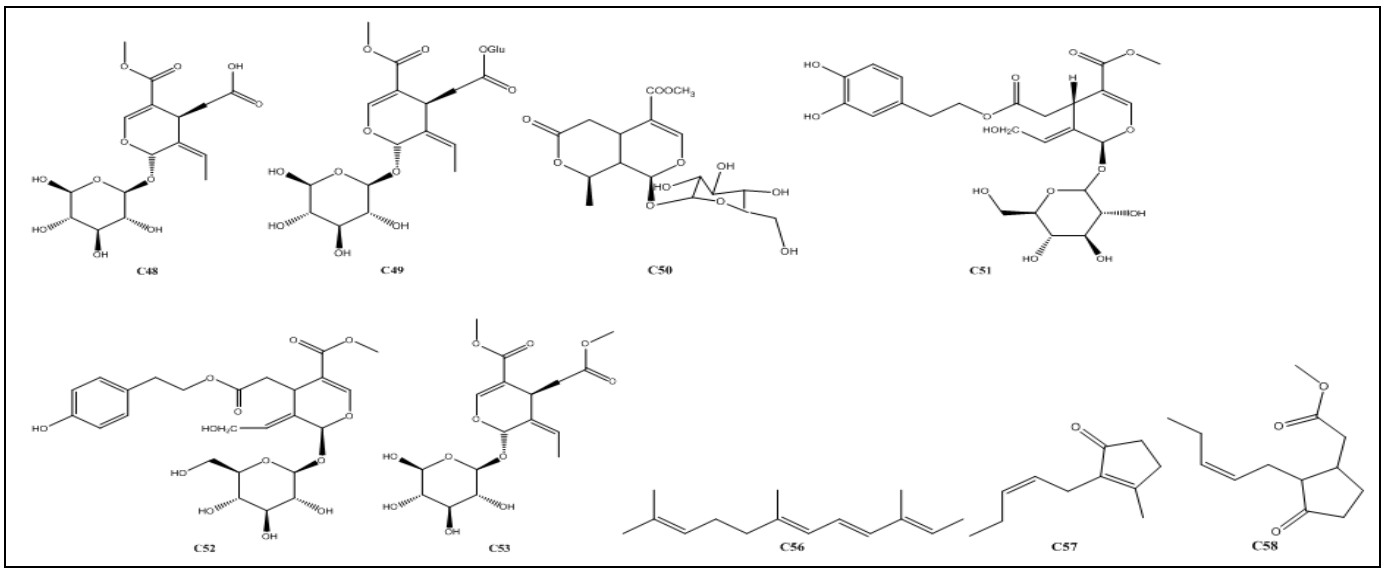
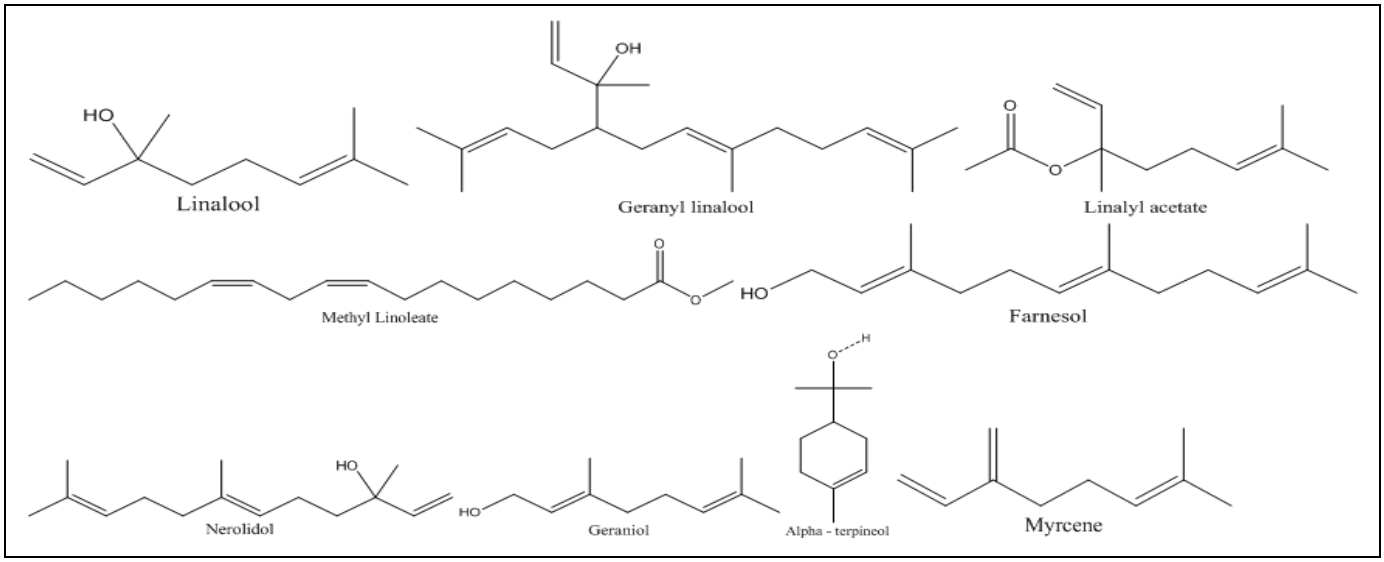
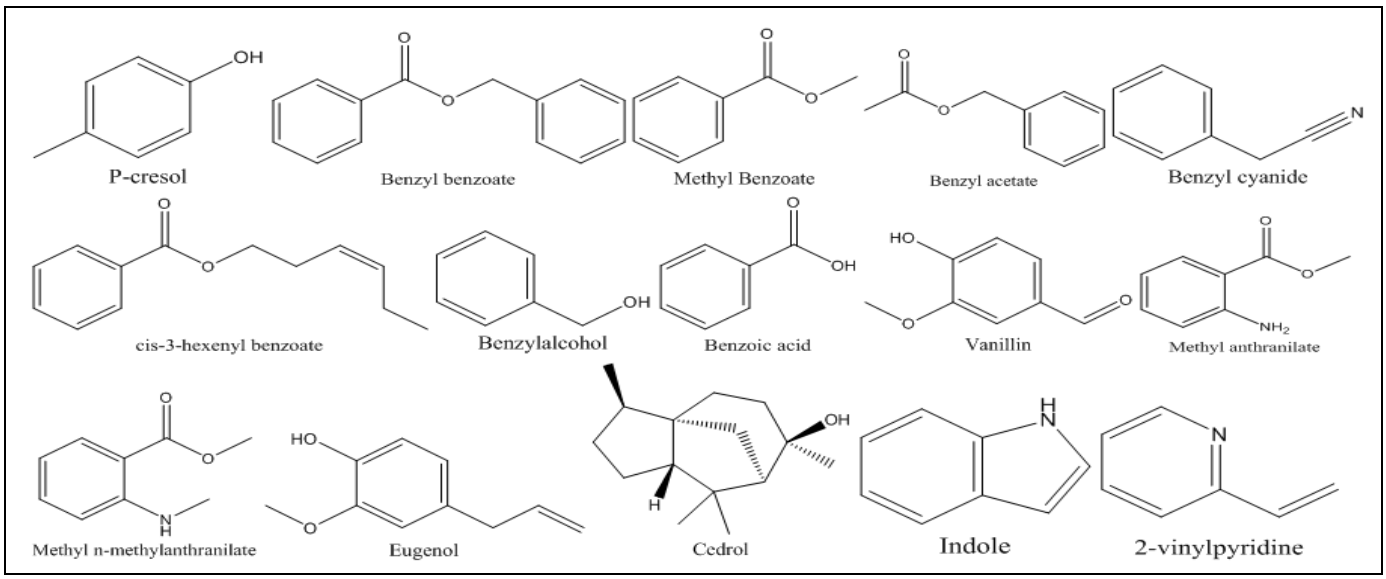


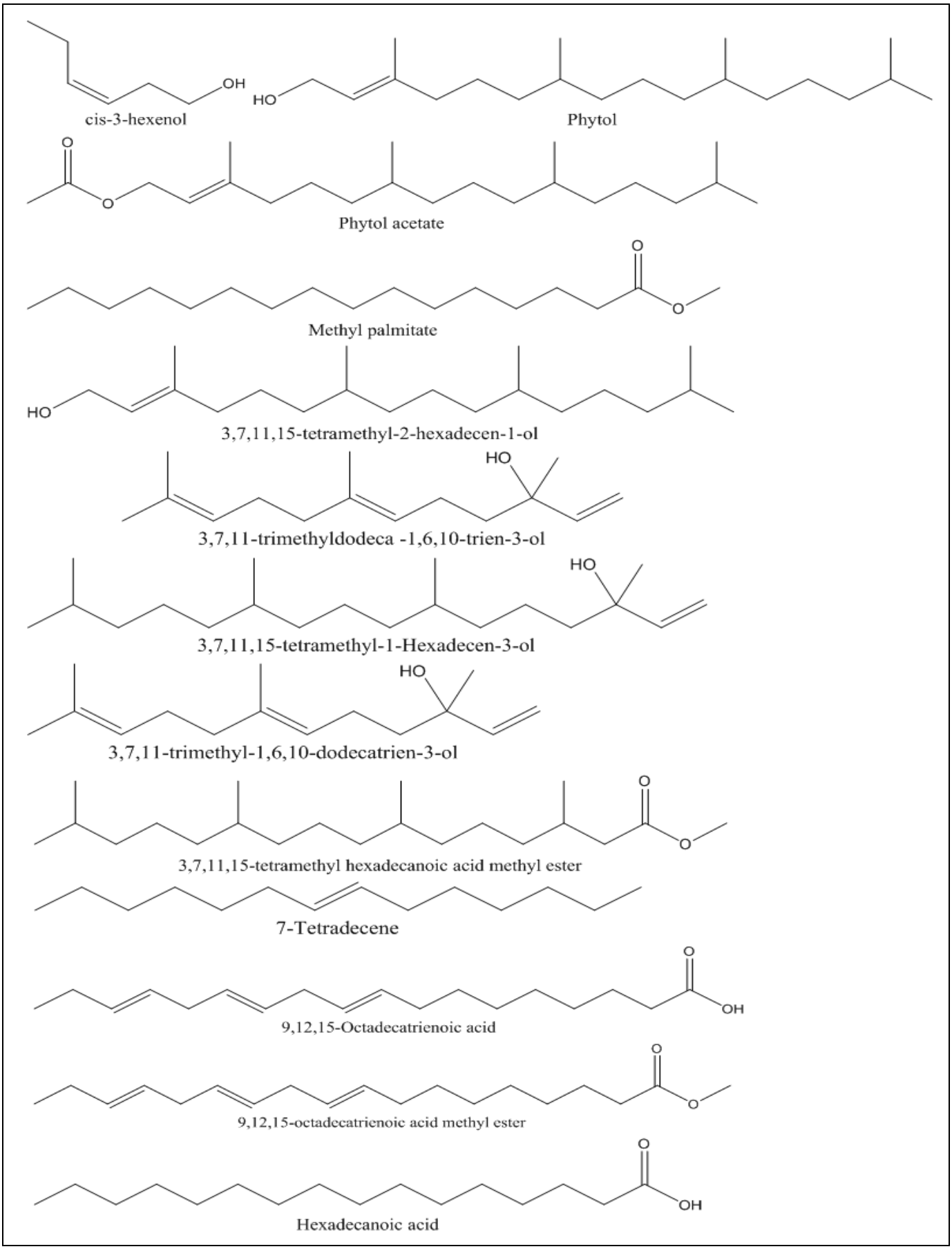
Terpenoids:

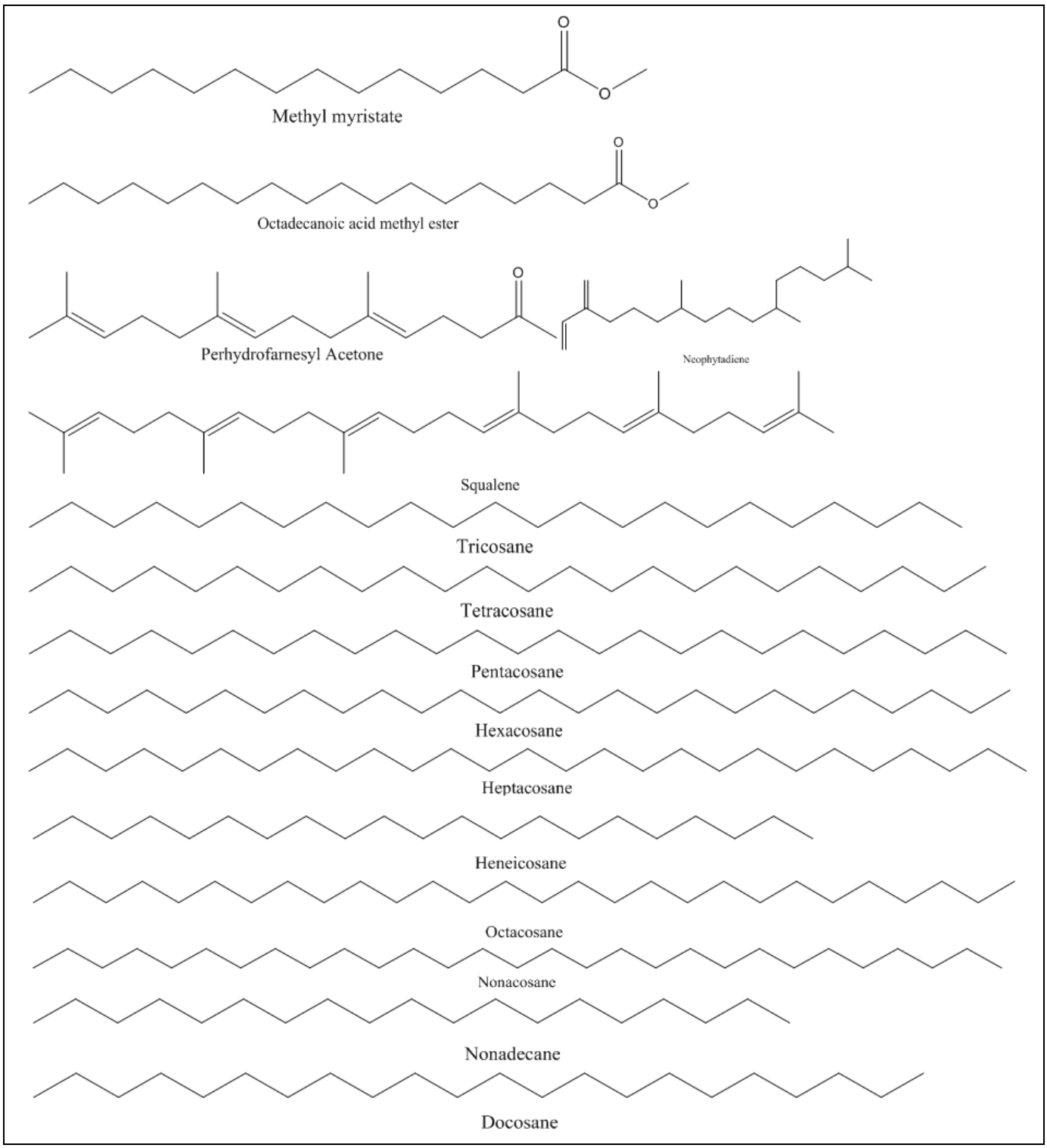


Aromatic Small Molecules:



Aliphatic Molecules:





3.3. Phytochemical Profile: The hydroethanolic extract of roots and leaves tested positive to steroids, alkaloids, triterpenoids, saponins, carbohydrates, tannins and flavonoids [37]. Phytochemical analysis of four different (n-hexane, chloroform, ethyl acetate and ethanol) flower extracts revealed the major presence of flavonoids. Fluorescence analysis and physicochemical properties were also evaluated for the flowers [51].

3.4. Medicinal Potential: The medicinal potential of *Jasminum grandiflorum* is well established. Largely the polar extracts from the leaves of the plant have been analyzed for antioxidant, antimicrobial, anti-inflammatory, anti-viral, anti-ulcer, and analgesic and wound healing potential. Antimicrobial assay of the methanolic and ethanolic extracts against gram-positive and gram-negative selective human pathogens revealed the

antimicrobial potential of the extracts to be significant. The anti-inflammatory activity of the leaf extracts is attributed to its high phenolic content and high antioxidant potential. Cell viability was found not affected at a concentration as high as 800µg/ml.

3.4.1. Wound Healing Potential: The ethanolic extract of flowers of *Jasminum grandiflorum* was assessed for its wound healing activity by excision and dead space wound models. Extract-treated rats exhibited 65% reduction in wound area compared to controls (54%) [33]. An ointment prepared from methanolic extract of leaves of *J. grandiflorum* was tested for its wound healing efficacy by the excision wound healing process. Tissue growth and collagen synthesis were significantly higher as determined by total hydroxyl proline, hexosamine, protein and DNA content. The rate of wound healing was enhanced as revealed from the enhanced rate of collagen synthesis and improved antioxidant status in the newly synthesized tissue [34.] Ethanolic flower extract of *Jasminum grandiflorum* was studied by incision wound (IW) and dead space wound (DW) models in Streptozotocin-induced diabetic Wistar albino rats [35]. Wound breaking strength, dry weight, hydroxyproline content, and histology were analyzed. There is a significant improvement in wound breaking strength (265.8 ± 10.4 *vs.* 332.5 ± 8.2), granulation tissue dry weight (26.1 ± 0.6 *vs.* 40.4 ± 0.3) and hydroxyproline content (19.3 ± 0.5 *vs.* 32.6 ± 0.8) in the treatment group compared to the control.

The wound healing activity of oil extract of the leaves of *Jasminum grandiflorum* by excision wound and burn wound models in albino rats was studied. A significant increase in the wound contraction rate is reported [36]. The hydroethanol root and leaf extracts of *Jasminum grandiflorum* were investigated for wound healing activity by the excision wound model. The epithelisation of leaf extract-treated wounds was found to be faster. While comparing the activity with control (55.72%), the leaf extract exhibited a higher reduction (61.346%) in the wound area [37].

3.4.2 Antimicrobial Activity: The various extracts of *Jasminum grandiflorum* leaves showed significant antimicrobial activity. A notable zone of inhibition was expressed by the chloroform extract of leaves against *Bacillus subtilis* (25 mm) and the ethanol extract against *E. coli* (21 mm). A low zone of clearance (8 mm) was exhibited by diethyl ether extract against *Streptococcus* sp. and ethanol extract against *Psuedomonas aeruginosa* and *Klebsiella pneumonia* [38].

At lower concentrations, the hot ethanol extract of leaves of *Jasminum grandiflorum* (10 µg/ml) was found to have statistically significant ($P \leq 0.05$) antimicrobial activity against *S. mutans* and *L. acidophilus* with MIC values of 6.25 µg/ml and 25 µg/ml respectively [39]. The fruit methanolic extract showed a significant inhibitory effect against the plant pathogen *Xanthomonas campestris* and the animal pathogen *Aeromonas hydrophila* with a zone of inhibition of 18.33 ± 0.47 mm and 13.66 ± 0.47 mm at 100 µg/ml respectively compared to that of the standard used [40].

The absolute from the plant exhibited medium to high activity against gram-positive *Enterococcus faecalis* and the gram-negative bacteria *Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoniae* and *Salmonella* species as well as against the yeast *Candida albicans* [30]. The absolute also showed moderate activity against the mycelial growth of *Collectotrichum gloeosporioides* [41]. A polyherbal formula developed from the aqueous distillates of a mixture of herbs including *J. grandiflorum* was assessed against *Staphylococcus aureus* and *Escherichia coli* [42].

3.4.3. Antioxidant Activity: The antioxidant potential of the polar extracts of leaves of *Jasminum grandiflorum* has been well investigated by *in-vivo* and *in-vitro* models. *In-vitro* antioxidant activity studies revealed significant free radical scavenging potential of the leaves. In the DPPH assay, the 50% inhibitory concentration of 15 µg/ml of the crude 70% ethanolic extract was found as potent as 12 µg/ml of ascorbic acid. The reductive ability at IC_{50} conditions was 19.5 µg/ml of the crude extract comparable to 15.5 µg/ml of quercetin. Nitric oxide radical scavenging was 98 µg/ml comparable to that of curcumin (92 µg/ml) at IC_{50} concentrations [43].

The leaf methanol extract significantly inhibited iron-induced lipid peroxidation and trapped ABTS, superoxide and hydroxyl radicals and effected

nitric oxide (NO) release without affecting the cell viability at 800 μg/ml concentration [44].

The essential oil of *Jasminum grandiflorum* was analyzed for its DPPH radical scavenging ability as a part of a study involving 45 oils [45].

3.4.4. Antiulcer Activity: The 70% ethanolic extract of leaves of *Jasminum grandiflorum* was tested for antiulcerogenic activity by aspirin + pylorus ligation (APL) and alcohol (AL) induced acute gastric ulcer models and ulcer-healing activity using acetic acid-induced (AC) chronic ulcer model in rats [43]. The antiulcer activity was attributed to the antisecretory and antioxidant potential of the leaves.

3.4.5. Antiviral Activity: *In-vitro* antiviral activity of the secoiridoid oleuropein isolated from flowers of *Jasminum grandiflorum* was evaluated by analysing hepatitis B virus (HBV) replication in HepG2 2.2.15 cell line and duck hepatitis B virus (DHBV) replication in ducklings *in-vivo*. It was found that oleuropein effectively blocked HBsAg secretion in HepG2 2.2.15 cells. Viremia in DHBV-infected ducks also reduced [46]. In a similar study, the effect of the compound 8-epi-kingiside derived from the buds of *Jasminum grandiflorum* on hepatitis B virus infection was assessed [47].

3.4.6. Analgesic Activity: The various solvent extracts of leaves of *Jasminum grandiflorum* were investigated for analgesic activity in albino rats and mice by formalin test and hot plate method. The aqueous extract of leaves expressed high analgesic activity at a dose of 200 mg/kg [48].

The antinociceptive activity of the hydroalcoholic extract of the leaves was analyzed by tail-flick and acetic acid-induced writhing method and its anticonvulsant activity were observed by maximal electroshock method and pentylenetetrazol method. At doses of 50, 100 and 200 mg/kg, the extract showed significant analgesic and anticonvulsant effects in experimental animals [49].

3.4.7. Anti Inflammatory Activity: The topical anti-inflammatory activity of a polyherbal formulation, *Jatyadi ghrita* containing *Jasminum grandiflorum* as one of the herbs was evaluated for anti-inflammatory activity. The preparation showed nearly 50 percent inhibition of croton oil-induced ear edema when compared to diclofenac sodium, which showed only 33% inhibition [50].

Anti- inflammatory activity of the solvent-free methanolic extract of the dried leaves was investigated by *in-vitro* and *in-vivo* models. It is recommended that the anti-inflammatory properties of *Jasminum grandiflorum* leaves are associated with its high phenolic content (2.25 ± 0.105 mg/l of gallic acid equivalent), reducing power and its free radical-scavenging property [44].

3.4.8. Anticholinesterase Activity: The aqueous and hydroethanolic extracts of the flower buds have the potential to inhibit CNS enzymes [14].

3.4.9. Anthelmintic activity: Anthelmintic activity of the various extracts of flowers of *Jasminum grandiflorum* was investigated with Indian adult earthworms. The ethanolic extract showed significant anthelmintic activity [51].

3.4.10. Toxicity Studies: Anti-toxicity studies with leaf methanol extract revealed that the tested animals were safe up to a maximum of 2000 mg/kg body weight in LD_{50} studies.

3.4.11. Allelopathic Potential: A wettable powder of the methanolic extract of the leaves of *Jasminum grandiflorum* inhibited germination and seedling growth of *Echinochloa crus-galli* (L.) Beauv weeds. This study indicates that the leaves also possess allelopathic potential [52]. The evaluation of the effect of the plant on physiological enzymes and oxidative species was reported [14].

3.5. Patents on Compounds and Medicinal Compositions of *Jasminum grandiflorum*: Most of the medicinal patents are formulations that contain *J. grandiflorum* as one of the components. The country-wise publication of patents on *J. grandiflorum* including the formulation patents is depicted in chart 2 below. A predominant number of patents are of Chinese origin while 2% are Indian patents. More recently, the extraction of high-purity oleuropein from *J. grandiflorum* flower bud has been patented [53]. Also, the process for the preparation of a polar hydroethanolic extract of flowers of the *J. grandiflorum* is patented [54]. Reports on medicinal formulations containing *J. grandiflorum* are classified based on various medicinal uses as in sections below.

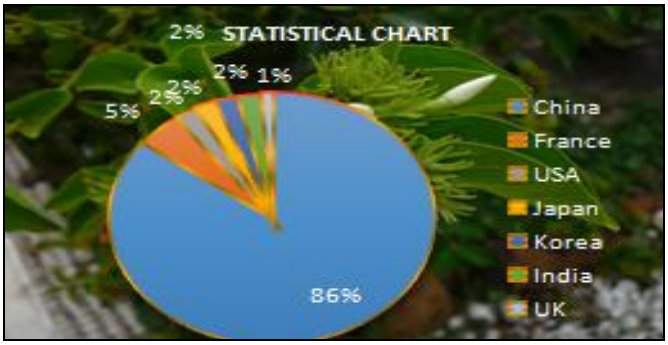


CHART 2: STATISTICS ON PATENTS ON *JASMINUM GRANDIFLORUM*

3.5.1. Dermatological Agents: A health preserving tea electuary for improving leucoderma is patented and prepared with *J. grandiflorum* along with other herbs and strengthens the body resistance and immunity, promotes blood circulation and remove blood stasis and nourishes the skin for whitening [55]. A Chinese medicine made with *J. grandiflorum* along with other herbs is reported as safe and effective for treatment of seborrheic dermatitis [56].

3.5.2. Neurological Aids: Chinese medicinal lotions for the treatment of post-herpetic neuralgia [57] and neurasthenia [58] have been patented. *J. grandiflorum* forms part of a nerve-calming tea soup granule capable of regulating human body internal organs, tonifying spleen and qi, clearing away the heart-fire and boosting brain and tranquilizing mind by nourishing the heart [59]. For the treatment of sciatica a traditional Chinese medicine comprising of 12-36 parts *J. grandiflorum* along with other herbs is patented [60].

3.5.3. Heat Clearing Medicinal Drugs: A heat-clearing tea extract [61, 62], herbal wine [63] and herbal tablet [64] comprising of *Jasminum grandiflorum* along with other herbs were patented.

3.5.4. Medicaments for Oral Ailments: A patent on a composition for treating stomatitis, mainly prepared from the herbal raw materials along with *J. grandiflorum* is used for eliminating swelling, stagnation and has significant curative effect [65].

3.5.5. Formulations for Promoting Blood Circulation: A blood circulation-promoting and pain-relieving formulation containing *Jasminum grandiflorum* along with other herbs is patented [66]. A Chinese medicinal preparation with *Jasminum grandiflorum* for treating hyperprolactinemia nourishes the liver and kidney, promotes blood flow for regulating menstruation, removes blood stasis, and with no adverse reaction has been patented [67].

3.5.6. Formulations for Cardiac Ailments: A Chinese medicinal composition consisting of *Jasminum grandiflorum* flowers along with herbs for treating cardiac asthma, with high safety and stable therapeutic effect is patented [68]. Yet another composition with flowers of *Jasminum grandiflorum* is also patented for treating cardiac ailments [69].

3.5.7. Formulations for Pulmonary Ailments: The Chinese medicine which shows a 95% effective rate for the treatment of lung dryness and phlegm stagnation comprises eight parts of *Jasminum grandiflorum* along with other herbs [70]. A lung protection drug made with *Jasminum grandiflorum* for the perioperative period has been patented [71].

3.5.8. Formulations for Gastrointestinal Ailments: A herbal tea containing *Jasminum grandiflorum* for the cure of stomach ailments is patented [72]. *Jasminum grandiflorum* is part of Chinese medicine used for treating stomach distension [73], gastric ulcer [74, 75] and mesenteric panniculitis [76] which are patented. A Chinese medicinal decoction of *Jasminum grandiflorum* has the efficiency to treat and cure gastrosis [77], gastrohelcosis and gastric ulcers [78]. The flowers of *Jasminum grandiflorum* are part of a Chinese medicinal umbilical patch useful for the treatment of abdominal postoperative bowel dysfunction [79] and for the treatment of stagnancy of qi and blood stasis type postpartum abdominal pain [80]. A pharmaceutical composition composed of *Jasminum grandiflorum* along with herbs for treating inflammation in the cecum is patented [81].

3.5.9. Formulations for Liver Related Ailments: Medicinal compositions with flower buds and flowers of *Jasminum grandiflorum* to cure hepatitis B [82] and other liver disorders like epilepsy [83], liver qi stagnation type cholecystitis [84], liver qi stagnation type globus hystericus [85] andreflux esophagitis [86] are patented. A herbal wine containing 15 to 20 parts *Jasminum grandiflorum* along with *Phyllanthus urinaria* and other herbal materials was prepared and patented as a heat-clearing liver-calming wine [87].

3.5.10. Formulations for Kidney Related Problems: A Chinese medicinal formulation containing *Jasminum grandiflorum* along with other Chinese herbs has efficacy of dredging stranguria and promoting diuresis [88] and for inducing diuresis to remove edema, warming kidneys and eliminating dampness by dieresis [89].

3.5.11. Formulations for Gynaecological Disorders: A Chinese medicine for treating blood stasis type amenorrhea prepared from *Jasminum grandiflorum* along with herbs [90] and medicine for the treatment of nodules of breast prepared from 20 weight parts of *Jasminum grandiflorum* along with other herbs [91] have been patented.

3.5.12. Medications for Relieving Depression: The umbilical sticking agent for treating stress incontinence is prepared from *Jasminum grandiflorum* with other herbs is patented [92]. A herbal health beverage containing *Jasminum grandiflorum* is one of the constituent herbs is found to be effective in clearing heat, toxic substances and for improving anxiety disorders [93] and for relieving depression [94].

3.5.13. Preparation of Essence for General Disorders: The essence prepared from tulips along with *Jasminum grandiflorum* is used for tranquilizing, improving intelligence, regulating nerve, clearing heat fire, and refreshing mind [95] and the essence prepared from lavender and pot marigold along with *Jasminum grandiflorum* and other herbs effective for tranquilizing, improving intelligence, regulating nerve, clearing heart fire, and refreshing mind [96] are patented.

An aromatic coating comprising of *Jasminum grandiflorum* micro-encapsulate with other fragrant agents and capable of purifying indoor air, and with a long-lasting aroma and scrubbing resistance is patented [97]. *Jasminum grandiflorum* essential oil is a part of the preparation of Glycyrrhiza essence. It is found to have long-lasting fragrance and good performance for removal of unpleasant smell [98] whereas the oil of *Jasminum grandiflorum* forms part of an essence [99] are patented.

3.5.14. Preparation of Surgical Drugs and Plasters: Patents on clinically proven aerosol inhalation solution prepared from *Jasminum grandiflorum* along with herbs for preventing bronchospasm after surgery [100] and a Chinese anesthesia plaster for the treatment of splenic embolization postoperative pain prepared from herbs including *Jasminum grandiflorum* has an excellent effect in relieving liver and for promoting coronary circulation [101].

3.5.15. Patents for Other Medicinal Uses: *Jasminum grandiflorum* flower forms a part of a health-care cigarette [102] and a capsule [103]. A herbal formulation containing essential oil of *Jasminum grandiflorum* tested for prevention of Alzheimer's disease [104], a Chinese medicinal powder used for treating the discomfort of incision [105] and the drug prepared for the treatment of peripheral facial paralysis [106] have been patented. A botanical preparation with *Jasminum grandiflorum* flowers for preventing and controlling fruit tree crown gall disease [107] is also patented.

3.5.16. Patents on Cosmeceutical Preparations: A fragrant cosmetic prepared from the essential oil of *Jasminum grandiflorum* [108], a perfume prepared from *Jasminum grandiflorum* with other chemicals used as inter alia perfumes, colognes, eau de toilettes and aftershave lotions [109], for improving the behavior of demented elders [110] and a low-cost perfume [111] are patented.

Fragrant products such as white cream and emulsion made with jasmine essence and benzyl derivatives along with other chemicals [112] and the essence obtained from the *Jasminum grandiflorum* absolute oil along with other chemicals [113] are patented. The ambergris-amber essence composed of *Jasminum grandiflorum* essential oil along with other plant essential oils used as flavoring products for white cream, emulsion and shampoo [114] is patented.

Other fragrant cosmetic products, perfumes, and essences prepared with *Jasminum grandiflorum* have been patented [115-118]. Skin-lightening compositions containing *Jasminum grandiflorum* extracts inhibit the generation of melanin so as to show skin-whitening effects [115] and provide good speckle-removing effect and skin elasticity [116].

A herbal composition effective against lotion 117 and mineral ion facial cleanser [118], lotion [119] and mineral ion facial cleanser [120] is patented.

CONCLUSION: This review highlights the herbal potential of *Jasminum grandiflorum.* The plant is host to a large number of chemical constituents which bestow medicinal value to the plant. Largely flavonoid glycosides, secoiridoids and terpenoidal molecules have been elaborated by this plant.

Extraction and yield enhancement strategies and quantification of constituents have been reviewed and documented in this work. The review also reveals that a number of patents have been registered for products and formulation containing *Jasminum grandiflorum* which also necessitates authentic growing and harvesting of the plant.

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