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PHYTOCHEMICAL AND PHARMACOLOGICAL PROPERTIES OF FIVE DIFFERENT SPECIES OF *JASMINUM*

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ABSTRACT

The Genus Jasminum belongs to the family Oleaceae, is widely distributed medicinal plant and has been used since ancient times. The Jasminum species (*Jasminum grandiflorum, Jasminum sambac, Jasminum flexile, Jasminum pubescens* and *Jasminum angustifolium*) have been used traditionally as antimicrobial, antiulcerative, antidepressant, anti-inflammatory, anticancerous, flavoring and fragrance agent and for the treatment of breast cancer, diarrhoea, fever, dermatitis, conjunctivitis, abdominal pain, asthma, abscess, uterine bleeding, toothache, headache, insomnia, dysentery and bellyache, diarrhoea and metrorrhagia. The jasmine oil is widely used in aromatherapy. The medicinal properties of Jasminum plants may be due to the presence of a broad spectrum of bioactive compounds such as Phenolics, terpenoids, coumarins, glycosides, steols, esters and fatty acids. The antimicrobial, anti-acne, spasmolytic activity and aromatherapy which is due to the combined effect of essential oils. The phytochemical investigations revealed that phenolic compounds are highly bioactive compared to the majority of terpenoids and other compounds. There are many reports which mentioned the therapeutic potentials of phenolic constituents such as the antioxidant &anti-aging, antiulcer, anti-inflammatory, lipid peroxidation, ACE inhibitor activity, vasodilation effect, wound healing, and protective activity. The present paper reviews the therapeutic potentials of phenolic compounds alongside with the phytoscreening and ethnobotanical aspects of Jasminum.

Keywords: Phenolics, Pharmacological activity, Terpenoids, metrorrhagia, Phenolics

INTRODUCTION

Medicinal plants constitute immense amount of raw materials for the synthesis of medicines, cosmetics and perfumes. In modern times plant derived natural products have been isolated for drug discovery and development. In the present scenario, research on plant materials for their therapeutic value is growing exponentially due to its lesser side effects compared to other systems of medicines. In most references, chemical constituents of plant origin are subdivided into three classes: alkaloids, terpenoids and phenolics. They possess wide range of pharmacological properties.

The phenolic compounds are the chemical compounds which possess one or more hydroxyl substitutents bonded to an aromatic ring. It is widely found in plant food. Among the natural phenolic compounds, of which several thousand structures are known and are classified according tho their structure. The flavonoids form the largest group compared to other groups such as simple monocyclic phenols, phenylpropanoids and phenolic quinines all exist in considerable numbers. The plant phenols have the ability to complex with protein through hydrogen bonding became a considerable nuisance to rhe plant biochemist. While the functions of some classes of phenolic compound are well known, but the role other classes is still a matter of speculation (Harbone, 1984).

Jasminum is a genus belongs to the family Oleaceae, which includes flowering climbing shrubs and vines. The genus *Jasminum* consists of over 2000 plants distributed all over the world. They are native to Eurasia India and Mediterranean regions. Of which 16 taxa are endemic to India and the genus is represented by 47 species 3 subspecies and 4 varieties (Green, 2003).They are mainly reported from Deccan Penisula, Eastern and Western Himalayas and Andaman and Nicobar Islands (Srivastava, 2002). 20 species are reported from flora of Presidency Madras (Gamble, 1921).

Taxonomical/ Scientific Classification:

Kingdom	:	Plantae
Division	:	Magnoliophyta
Class	:	Magnoliopsida
Order	:	Lamiales
Family	:	Oleaceae
Genus	:	Jasminum

The aim of this work was to analyze phenolic compounds found in some species of *jasminum* such *as Jasminum grandiflorum, Jasminum sambac, Jasminum flexile, Jasminum pubscens*, *Jasminum officinale* and *Jasminum angustifolium* with its pharmacological properties.

Phytochemical Reports on *Jasminum*

Several reports focused on the phytochemical constituents of different species of *Jasminum*. The preliminary phytochemical screening revealed the presence of antioxidants, coumarins, cardiac glycosides, essential oils, phenolics, saponins and steroids (Table1). The isolation and characterisation of chemical components such as Iridoids, secoiridoids, volatile oils, phenolics, tannins and flavonoids, which have been reported as major constituents of *Jasminum* and it is documented in detail (Table 2).

Jasminum grandiflorum

There are many published reports on the chemical constituents of different parts of *Jaminum grandiflorum*. Secoiridoid glycosides, demethyl-2”-epifraxamoside 2”-epifraxamoside, jasminanhydride (Sadhu *et al.,* 2007), isoquercitrin, oleacein, 2-(3,4- dihydroxy phenyl)-ethanol, ursolic acid (Somanadhan, 1998), resin, 3,4-dihydroxy benzoic acid, salicylic acid, 2-hydroxy-30, 40-dihydroxyacetophenone and oleanolic acid were reported from the leaves of *J. grandiflorum*. Flower consists of the following constituents such as linalool,vanillin,Cis-3-hexenol, indole,2-vinyl pyridine, isophytol, farnesol, myrcene, geraniol, geranyl linalool, αterpineol, cis-3-hexenyl benzoate, benzyl benzoate, linalyl acetate, nerolidol, phytol, eugenol, benzyl alcohol, methyl anthranilate, methyl benzoate, benzyl cyanide, benzyl acetate, methyl dihydrojasmonate, jasmone, methyl- N-methyl anthranilate, methyl palmitate, methyl linoleate, p-cresol (Rastogi and Mehrotra, 1999). Jamine oil consist of Methyl jasmonate (Rastogi and Mehrotra, 1999), benzyl benzoate,P-cresol, linalool, benzyl benzoate, linalyl acetate, benzyl alcohol, indole, jasmone, methyl anthranilate, geraniol, nerol, 1-α-terpineol, d and dl-linalool, γ-jasmolactone, farnesol, nerolidol, racemic (5-pent-2-enyl)-5,1-pentanolide and eugenol (Sharma *et al*., 2005; Rastogi and Mehrotra, 2001; Sandeep, 2009). Methyl anthranilate, benzyl alcohol, indol, benzyl acetate, and the terpenes linalool and linalyl acetate were found in ethanolic extracts of *J. grandiflorum* flowers (Nayak and Mohan, 2007).

The liquid Co_2 extraction of *J. grandiflorum* was enriched with benzenoids and terpenoids. The major compounds, such as (E, E)-α-farnesene, benzyl acetate, and (Z)-3-hexenyl benzoate, along with compounds like (Z)-jasmone, indole, methyl anthranilate, (Z)- (Z)-methyl epi-jasmonoate and methyl jasmonoate are responsible for the high diffusivity of the *jasminum* fragrance (Prakash *et al*., 2012). The chemical composition of *Jasminum grandiflorum* was evaluated using GC and GC/MS and the major constituents identified were, benzyl benzoate (20.7%), linalool (8.2%), benzyl acetate (23.7%), isophytol (5.5%), geranyl linalool (3.0%), phytol (10.9%), methyl linoleate (2.8%) and eugenol (2.5%) (Jirovetz, 2007).

Jasminum sambac

The preliminary screening shows the presence of phytoconstituents such as carbohydrates, alkaloids, phenols, flavonoids, terpenoids, proteins, tannins, saponins and phytosterols (Kalaiselvi and Kalaivani, 2011). The major jasmine oil components are benzyl acetate and linalool, which is responsible for the typical fragrance of jasmine oil (Ye *et al*., 2015). The major phyto-constituents present in *J. sambac* were iridoidal glycosides, benzyl 6-O-β-Dxylopyranosyl-β-D-glucopyranoside (β-primeveroside), linalyl 6-O-malonyl-β-D-glucopyranoside, 2-phenylethyl β-primeveroside, 2-phenylethyl 6-O-α-L-rhamnopyranosyl-β-D-glucopyranoside (β-rutinoside) (Inagaki *et al.,*1995; Zhang *et al*., 1995), dotriacontanol, oleanolic acid, dotriacontanoic acid, daucosterol, and hesperidin (Zhang *et al*., 2004). Benzyl acetate, indole, Z-3-hexenyl benzoate, E-E-α-farnesene, benzyl alcohol, linalool, and methyl anthranilate were main volatile components present in jasminum (Edris *et al*., 2008; Ito *et al*., 2002). The volatile organic compounds from flowers of *J. sambac* were cis-3-hexenyl acetate, linalool, (E)-β-ocimene, benzyl acetate, and (E, E)-α-farnesene were determined using using solid phase microextraction fibers and Gas chromatography with Mass spectroscopy detection (Pragadheesh *et al.,* 2011). Major constituents identified in essential oil were, eugenol ,phenyl ethyl alcohol, geranial, citronellol, farnesol, geranyl acetate, 2-phenyl ethyl acetate, citrinyl acetate, citral (mixture of cis and trans), and benzyldehyde (Younis *et al*., 2011).

Jasminum flexile

The major constituents were characterized in *J. flexile* flower absolute were benzyl benzoate, methyl linolate, (2E, 6E)-farnesol, benzyl salicylate, and benzyl acetate (Braun *et al*., 2009).

Jasminum pubescens

The flowers and leaves of *J. pubescens* essential oil yields were 0.04% and 0.02% (w/w) respectively. GC and GC-MS analysis have resulted in the characterization of 63 and 64 compounds, representing 91.9% for the flowers and 95.0% of the total oil for the leaves. The essential oil constituents found in *J. pubescens* were benzyl salicylate, β-Pinene, δ-3-Carene, α –Pinene, (E,E)-2,4-Heptadienal, 6-Methyl-5-hepten-2-one, 2-Pentyl furan, 1-Hexanol, (E)-2-Hexen-1-ol, 1-Hexanol, (E)-2-Hexen-1-ol, 1-Hexanol, Octanal, n-Pentacosane, n-Tetracosane, Abieta-7,13-dien-3-one, n-Tricosane, n-Docosane, Abieta-8(14),13(15)-diene, Methyl octadecanoate, n-Heneicosane, Methyl linoleate, Abietadiene, Kaurene, n-Peicosane, n-Hexadecanoic acid, Methyl hexadecanoate, n-Nonadecane, (E,E)-α-Farnesyl acetate, Hexadecanal, Octadecane, Benzyl benzoate, Pentadecanal, n-Heptadecane, epi–α-Bisabolol, α-Bisabolol, Tetradecanal, Humulene epoxide II, β-Atlantol, n-Hexadecane, (E)-2-Phenyl ethyl tiglate, Caryophyllene oxide, Hexyl benzoate, (Z)-3-Hexenyl benzoate, trans-Nerolidol, Tridecanal, Benzyl tiglate, (Z,E)-α-Farnesene, Phenyl ethyl-3-methyl butanoate, (E)-β-Ionone, (E)-β-Farnesene, α-Humulene, (E)-Geranyl acetone, Aromadendrene, (E)-α-

Ionone, (E)-β-Damascenone, α-Copaene, Eugenol, (E,E)-2,4-Decadienal, (E,E)-2,4-Decadienal, Undecanal, Isobornyl acetate, (E)-2-Undecenal, Isobornyl acetate, Nonanoic acid, (E)-2-Decenal, Decanal, α-Terpineol, Methyl salicylate, p-Cymen-8-ol, 4-Terpineol, Phenyl ethyl formate, p-Mentha-1,5-dien-8-ol, (E)-2-Nonenal, (E,Z)-2,6-Nonadienal, Benzyl nitrile, cis-Verbenol, cis-Limonene oxide, Nonanal, α-Campholenal, 1-Octanol, Phenylacetaldehyde, p-Cymene (Temraz *et al*., 2009).

Jasminum officinale

Six iridoid glycosides were identified from the buds of *J. officinale* var. *grandiflorum* as jasgranoside B (new compound, loganin, deacetyl asperulosidic acid, aucubin, 6-O-methy-catalpol, 8-dehydroxy shanzhiside. Except jasminoside, compounds 2-6 were isolated for the first time from *Jasminum officinale* (Zhao *et al*., 2011) and identified seven glycosides were kaempferol-3-O-alpha-L-rhamnopyranosyl (1-->3)-[alpha-L-rhamnopyranosyl (1-->6)]-beta-D-galactopyranoside, oleoside-11-methyl ester ,kaempferol-3-O-rutinoside, 7-glucosyl-l1-methyl oleoside, ligstroside, 7-ketologanin and oleuropein (Zhao *et al*., 2007).

From the above data it is clear that majority of the phytochemical constituents belongs to terpenoids especially essential oils. Phenolics, glucosides, sterol and esters forms least in number compared to terpenoids which is represented in Figure1.The important phenolic compounds which has therapeutic potential were Hesperidin, Isoquercitrin, Oleacein, P-cresol, Salicylic acid, Ursolicacid,Vanilin, 3,4-dihydroxybenzoic acid Eugenol, 4- p-coumaroylquinic acid, Quercetin, Kaemferol, Oleuropein and oleanolic acid (Figure 2)

Ethnomedical Importance of Jasminum

The Jasmine flowers are characterized by a very pleasant aroma and are of great significance in industry, food and medicinal applications. They are the major source of raw materials for the production of high grade perfumes. The most important species in cosmetics, flavouring of food, perfumery and medicinal applications are *Jasminum grandiflorum, J. officinale and J. sambac*. The *J. grandiflorum* flowers and leaves are largely used in folk medicine to prevent and treat breast cancer. *J. grandiflorum* flowers are useful to women in preventing uterine bleeding and in the treatment for breast cancer (Joshi, 2000). It is widely used in Ayurvedha as an antileprotic, anticancerous, antiulcerative, for skin diseases and wound healing. The plant possess beneficial effects such as anthelmintic, odontalgic, emollient thermogenic, tonic, aphrodisiac, skin diseases, antiseptic, deobstruant, aromatherapy, suppurative, in fixing loose teeth, ulcerative stomatitis, leprosy, otalgia, wounds, andottorrhoea (Sandeep, 2009). The jasmine oil is used for the treatment of stress, anxiety and pain and used as an antidepressant.

The *Jasminum sambac*is widely used in scented tea processing due to its elegant fragrance and versatile applicability (Ito *et al*., 2002). The flowers are used in as traditional medicines to treat many diseases such as breast cancer, diarrhoea, fever, dermatitis, conjunctivitis, abdominal pain, asthma, abscess, uterine bleeding and toothache. In China, the leaf parts have been utilized for the treatment of quadriplegia gall, dysentery, and bellyache (Zhang *et al*., 1995; Kunhachan *et al*., 2012; Widowati *et al*., 2018). Jasmine essential oil is increasingly used as a fragrance in food, perfumes and cosmetic industries. In aromatherapy, jasmine oil is used as a therapeutically active agent (Hongratanaworakit, 2010). Jasmine flowers are used as an alternative for bromocriptine and also an effective method of suppressing puerperal lactation (Shrivastav *et al*., 1988). Leaf part is usually used in the treatment of acne and the shortness of breath. The root part is believed to accelerate fracture healing and used to cure headache and insomnia (Alrashdi *et al*., 2012).

The dried leaves of *J. pubescens* are used to treat ulcers including the one of the mouth in the form of poultice and skin diseases anotorrhea. The flowers have been used for the treatment of intracranial disease, diarrhoea, metrorrhagia, biliary infection, oedema heartburn, and as antidote for poisons (Temraz *et al*., 2009).The leaves of *J. officinale* are used as a spice and flowers as flavouring agent in desserts.

Pharmacological Properties of Jasminum

Antimicrobial Activity

The *J. grandiflorum* sample were tested for antimicrobial activity using agar dilution and agar diffusion methods against Gram-positive and Gram-negative bacteria, as well as against the yeast *Candida albicans*. The jasmine absolute showed medium to high activity against the Gram-positive bacterium *Enterococcus faecalis*, against the Gram-negative *bacteria Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumonia and Salmonella s*pecies, as well as against the yeast *Candida albicans* were eugenol and three synthetic antibiotics used as reference compounds (Jirovetz *et al*., 2007).The result obtained from the testing shows that no single component or group responsible for the antimicrobial activity of jasmine absolute sample, it was dependant partly antagonistic and synergistic effect of all oil components. Invitro antimicrobial activity of aqueous and ethanol (cold and hot)extracts of leaves of *J. grandiflorum* and *Hibiscus rosa-sinensis* were studied against *Streptococcus mutans* and *Lactobacillus acidophilus* using the agar well diffusion method and stastically analysed using one- way analysis of variance (ANOVA). Resultanly, hot ethanol *Jasminum grandiflorum* (10 µg/ml) and *Hibiscus rosa-sinensis* (25 µg/ml) extracts at lower concentration were shown to have significant antimicrobial activity with minimum inhibitory concentration (MIC) values of 6.25µg/ml and 25 µg/ml, respectively. Except for hot water *Hibiscus rosa-sinensis* extract the zone of inhibition of all the extracts significantly increased with increasing concentration of the extract (Nagarajappa *et al*., 2015).

Antiviral efficacy against hepatitis B virus replication of oleuropein isolated from *Jasminum officinale L.* var. *grandiflorum* was studied in HepG2 2.2.15 cell line in vitro and in ducklings in vivo. There was anti-HBV activity in HepG2 2.2.15 cells test in vitro and duck hepatitis B virus (DHBV) infected ducklings test in vivo (Arun *et al*., 2016; Zhao *et al*., 2009).The antimicrobial activity of five herbs including *J. officinale* used in Ayurveda practices against one standard strain each of *Candida parapsilosis* (ATCC 22019), *Candida albicans* (ATCC 10231), and six Methicillin Resistant *Staphylococcus aureus* (MRSA) clinical isolates were determined using the well diffusion method. Based on zone of inhibition and Minimum inhibitory concentration (MIC), the ethanolic leaf extract of *J. officinale* had shown antimicrobial activity against Methicillin Resistant

Staphylococcus aureus (Gunasekara *et al*., 2017). Similarly, *J.officinale* extracts showed variable antibacterial activity against human pathogenic bacteria such as *Staphylococcus aureus, Bacillus subtilis, Proteus vulgaris, Pseudomonas aeruginosa, and Escherichia coli* using agar well diffusion method (Khan *et al*., 2013). Antibacterial activity of Jasmine essential oil (*J. sambac*) against *Escherichia coli* (*E. coli*) was determined by tube dilution method. The Minimum inhibitory concentration (ranged between 1.9-31.25 ul/ml. Hence the antibacterial potential of *J. sambac* was due to the combined effect of all essential oils (Rath *et al*., 2008).

Antiulcer Activity

The ethanolic extract (70%) of leaves of *J. grandiflorum* were tested for antiulcer and antioxidant activities. Antiulcerogenic activity of extract (100 and 200 mg/kg, b.w. orally) was evaluated employing alcohol (AL) and aspirin + pylorus ligation (APL) induced acute gastric ulcer models and ulcer-healing activity using acetic acid induced (AC) chronic ulcer model in rats. The role of antioxidant principles in the antiulcerogenic activity of the extract has been assayed by using the methods like superoxide anion scavenging activity, 2, 2- diphenyl-1-picrylhydrazylhydrate (DPPH) assay, reductive ability, nitric oxide scavenging activity and total phenolic content. In comparison with the standard drug famotidine, there is a significant dosedependent decrease in the ulcerative lesion index produced by all the three models in rats. The reduction in total acidity, gastric fluid volume and an increase in the pH of the gastric fluid in APL rats proved the antisecretory activity of the plant extract. The Histopathological studies proved that the extract completely healed the ulcer within 20 days of treatment in AC model. The free radical scavenging activity increase with increasing amount of the extract and depend on concentration of the plant extract (Arun *et al*., 2016; Umamaheswari *et al*., 2007). Antiulcer potential using APL-induced acute gastric ulcer models in albino rats were performed with Hydro alcoholic extract of leaves of *J. grandiflorum* at a dose of 100 and 200 mg/kg, orally. The result showed an increase in the pH of the gastric fluid and a significant reduction in gastric fluid volume, free acid, total acid and hence indicated the antisecretory and potential antiulcer activity of leaves of *J. grandiflorum* (Arun *et al*., 2016; Nilesh *et al*., 2009).

Anti-inflammatory Effect:

The anti-inflammatory potential of aqueous extracts from two herbal teas (*Annona muricata L.* and *Jasminum grandiflorum* L.) and relation with phenolic compounds revealed that aglycones had more capacity to inhibit nitric oxide (NO) and phospholipase A2 (PLA2) than their corresponding glycosides, quercetin being clearly the most potent one (IC50 = 7.47 and 1.36 μM, respectively). Similarly, 5-Ocaffeoylquinic acid, at 1.56 μM, could also inhibit PLA2 (ca. 35%). The study suggests that the consumption of both herbal teas may be a preventive approach to inflammatory disorders (Oliveira *et al*., 2017).

Traditionally the root and leaves of *J. sambac* were used in the treatment of inflammation, fever and pain. Enzymes such as alkaline phosphatase (ALP), aspartate transaminase (AST) and alanine transaminase (ALT) were elevated in acute and sub-chronic inflammation. A significant reversal of all biochemical parameters (except ALT) in tissues was observed in rats. Scientifically it is proven that phenolic compound especially quantity of hespiridin (HPLC) was found to be 4.25 % w/w and it is directly correlated with anti-inflammatory, analgesic and antipyretic activity of *J. sambac* (Sengar *et al*., 2015).

The anti-inflammatory activity of isolated compounds from *J. officinale* such as four new sesquiterpenoids, including three nor-cinalbicane type sesquiterpenoids, named Jasminol A, G, H and one eremophilene-type sesquiterpenoid, named Jasminol B were evaluated using lipopolysaccharide (LPS)-induced murine macrophage RAW264.7. The half maximal inhibitory concentration (IC_{50}) values of 20.56 ± 1.31, 30.12 ± 0.89, 30.35 ± 2.72 and 31.60 ± 1.69 μM, respectively, these compounds were exhibited a moderate inhibition of LPS-induced nitric oxide (NO) production in RAW264.7 cells (Lu *et al*., 2019).The ethanolic extract of 11 traditionally used Jordanian plants including *J. officinale* were studied for anti-nociceptive effect by using acetic acid-induced writhing and hot-plate test in mice. The result showed that the anti-nociceptive and anti-inflammatory effects were dose dependent and *J. officinale* has an anti-inflammatory activity against acute (xylene-induced ear oedema) and chronic (cotton-pellet granuloma) inflammation (Atta and Alkofahi, 1998).

Wound Healing Activity

The wound healing activity of flower extract of *J. grandiflorum* was studied using excision and dead space wound models in rats at a dose of 250 mg/kg body weight orally for 10 days. When compared to controls (54%, the treated rats exhibited 65% reduction in the wound area. The result showed that hydroxyproline content and wet and dry granulation tissue weight and in a dead space wound model were increased significantly when compared to controls. Histological studies of the tissue obtained from the extract-treated group showed more fibroblasts, increased well organized bands of collagen, and few inflammatory cells when compared to controls which showed inflammatory cells, scanty collagen fibers and fibroblasts which suggests the role *of J. grandiflorum* flower extract in wound healing (Nayak and Mohan, 2007). The wound healing potential of methanolic extract of *J. grandiflorum* leaves showed rise in rate of collagen synthesis and the antioxidant rate also increased in the newly formed healed tissue when excision wound model was performed for 12 days (Chaturvedi *et al*., 2013).The ethanolic extract of *J. grandiflorum* flowers were effective in diabetic wound healing in Wistar albino rats by increasing tissue granulation and wound contraction (Hirapara *et al*., 2017). Similarly, the hydroalcoholic extract of leaves of *J. grandiflorum* was studied for its wound healing activity at a dose of 250 mg/kg body weight using excision and dead space wound models in rats where standard used was sulfathiazole ointment (Mishra *et al*., 2010). The mucosdhesive containing *J. grandiflorum* leaves were effective in reducing wound diameter and speed up the recovery process which is revealed by evaluation of its healing effect on oral biopsy ulcers (Mortazavi *et al*., 2020).

Anti-Acne Activity

The essential oil of *J. grandiflorum* was evaluated for Anti-acne activity towards *Propionibacterium acnes* and in vitro toxicology against three human cancer cell lines. The result showed that significantly stronger cytotoxicity of essential oil on human prostate carcinoma cell (PC-3) than on human lung carcinoma (A549) and human breast cancer

(MCF-7) cell lines and effective anti-acne activity against *Propionibacterium acnes* (Zu *et al*., 2010).

Spasmolytic Activity

Spasmolytic activity of Jasmine (*J. grandiflorum*) invitro using guinea pig ileum was likely to be mediated through cyclic adenosine monophosphate (cAMP), and not through cyclic guanosine monophosphate (cGMP). Essential oil components such as geranium oil, geraniol, citronellol and linalool favourspasmolysis of smooth muscles. Here, the spasmolytic activity is directly correlated with essential oil components in jasminum (Lis-Balchin *et al*., 2002).

Angiotensin Converting Enzyme (Ace) Inhibitor Activity

Isolation of oleacein was performed using bioactivity guided fractionation of extract of aerial parts of *J. grandiflorum*. The ACE studies of aerial parts of *J. grandiflorum* showed that the IC_{50} values were between 26-66 Mm (Nagarajappa *et al*., 2015). The ACE inhibitors of *J. grandiflorum* used to cure chronically elevated blood pressure and thereby reduce hypertension, which is an important cause of cardiovascular diseases (Kamrani Rad *et al*., 2019). The n-butanol fractions of the methanolic extract of *Jasminum grandiflorum* subsp. *floribundum* aerial parts showed a significant ACE and renin inhibition, Lisinopril and Aliskiren were used as standard drugs (24.66 ± 2.41 ng/mL vs. 18.37 ± 1.21 ng/mL and 141.14 ± 5.28 ng/mL vs. 447.87 ± 3.2 ng/mL, respectively) and also a strong antioxidant activity (El-Shiekh *et al*., 2020).

Vasodilation Effects

In endothelial cells in the aortic vessel, the vasodilation effect of the Jasmine flower extract was performed. The result showed that at a dose of 400 μg/mL of flower extract reduced the contraction to lower than 43% of the maximal contraction and the vasorelaxation effect of the ethanolic *J. sambac* flowers extract is endothelium dependent. It has been reported that flavonoids were responsible for the vasorelaxant property of most plant extracts (Heiss *et al*., 2010).Thus the vasodilation activity of *j. sambac* flower extract should be attributed to the high flavanoid content.

Aromatherapy

The use of essential oils of *jasminum* especially *J. sambac*in aromatherapy massage caused significant increases of systolic and diastolic blood pressure, breathing rate and blood oxygen saturation which indicated an increase of autonomic arousal. The constituents in the jasmine oil group at the emotional level, rated themselves as, more vigorous, more alert and less relaxed than constituents in the control group. The result shows an increase of subjective behavioral arousal. In conclusion, our results demonstrated that jasmine oil has stimulating/activating effect and hence it has been used in aromatherapy for uplifting mood in humans and relief of depression (Joshi, 2000; Hongratanaworakit, 2010; Ayaz *et al*., 2017). The *J. officinale* extract has moderate effect of aroma therapy massage on pain severity and labor outcome in 156 nulliparous women in labor were randomly selected and grouped into Jasmine, Salvia and control groups (52 in each group) in comparison with *Salvia officnale* (Kaviani *et al*., 2014).

Antioxidant & Antiaging Activities

The six phenolic compounds such as 5-dihydrocaffeoylquinic acid, dihydromethoxy caffeoylquinic acid, 4-p-coumaroylquinic acid, quercetin-3-O-(2,6-di-rhamnosyl) glucoside, kaempferol-3-O-(2,6-di-rhamnosyl) glucoside, quercetin-3-O-(6-rhamnosyl) glucoside were identified from *J. grandiflorum* flowers have potential to treat Central Nervous System Disorders (CNS) and tofavour antioxidant protection (Ferreres *et al*., 2014).

Antioxidant potential of *J. sambac* flower extract were measured through Ferric Reducing Antioxidant Power (FRAP), 2,2-diphenyl-1- picrylhydrazyl (DPPH) scavenger and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS)-reducing activities. Anti-aging properties were measured by inhibitory activities of elastase, collagenase and hyaluronidase. Phytochemical screening showed presence of terpenoids in high level and triterpenoids, flavonoids and phenols in low level. The extract showed higher DPPH-scavenging activity (IC_{50}=94.13 ± 10.54 μg/ml) than eugenol (2.28 ± 0.12 μg/ml), but lower than hesperidin (226.34 ± 4.96 μg/ml). The ABTS-activity of extract showed lowest (IC50=39.20 ± 0.45 μg/ml) compared to hesperidin and eugenol (IC_{50}= 8.10 ± 0.60 and 1.56 ± 0.03 μg/ml, respectively). In FRAP-reducing activity, hesperidin, and eugenol showed the lowest activity at highest concentration (65.46, 178.16 and 402.42 μM Fe (II)/μg) respectively). When compared with hesperidin, and eugenol, flower extract showed the lowest, anti-elastase (IC50=249.94 ± 16.51 μg/ml), anticollagenase activity (IC50=339.30 ± 7.87 μg/ml) and anti-hyaluronidase (IC50=269.26 ± 90.52 μg/ml). Overall, flower extract has low antioxidant activity compared to hesperidin and eugenol, as well as low, anti-elastase, anti-collagenase and anti-hyaluronidase activities (Widowati *et al*., 2018). The flower extracts of *J. sambac* fermented with *Lactobacillus rhamnosus* studied for antioxidant and collagen-promoting effects on UVB/H_2 O_2 -induced HS68 dermal fibroblast cell damage. Resultantly, the flower extract could enhance the viability of HS68 cells. The extract can effectively reduce the UVB/H_2 O_2 -induced dermal cell aging such as excessive production of reactive oxygen species, degradation of collagen, activation of MAPKs and premature senescence. Hence, indicating an important role in skin aging therapy (Ho *et al*., 2021).

The total phenolic content of some selected jasminum species was tested with 80% ethanolic extract of leaves using Folin–ciocalteumethod. The result shows that *J. officinale* has second highest phenolic value of 133.4 ± 0.28 μg GAE/mg (GAE- gallic acid equalent) and *J. sambac* possess moderate phenolic value of 50.2 ± 0.04 μg GAE/mg. A higher antioxidant activity observed for *J. officinale* compared to other species (IC50 value-76.6 2 μg/ml) and *J. sambac* show moderate antioxidant activity. Hence, the phenolic concentration were responsible for the antioxidant potential (El-Hawary *et al*., 2019). The ethanolic extract of *J. angustifolium* showed significant antioxidant activity in hydrogen peroxides, DPPH, nitric oxide, and hydroxyl radical scavenging methods were ascorbic acid as reference compound. When comparing the IC_{50} values, the ethanol extract showed significant antioxidant potency than ascorbic acid (Asirvatham *et al*., 2012).

Gastroprotective Effect

The ethanolic extracts of *J. sambac* leaves against acidified ethanol-induced gastric ulcers in rats were performed in order to study the gastroprotective effects. The seven groups of rats were orally pre-treated with carboxymethyl cellulose (CMC) as normal group, 20 mg/kg of omeprazole as positive group, CMC as ulcer group, 62.5, 125, 250, and 500 mg/kg of extract as the experimental groups. An hour later, acidified ethanol solution was given orally to the ulcer control, the experimental groups and positive control and CMC was given orally to normal group. Acidity of gastric content, ulcer areas, the gastric wall mucus, histology and immunohistochemistry of the gastric wall were assessed. Gastric homogenates were analysed for superoxide dismutase (SOD), prostaglandin E2 (PGE2) and malondialdehyde (MDA) content. In comparison with omeprazole the ulcer group exhibited significantly severe mucosal injury or extract which shows significant gastroprotective activity and shows significant reduction of ulcer area grossly, and histology showed significant reduction of leucocytes infiltration of submucosal layer and edema compared with ulcer group. Immunohistochemistry, the rats pretreated with extract showed down expression of Bax protein and over expression of Hsp70 protein. The high levels of PGE2, significant increase in the pH, mucus of gastric content and, SOD and reduced amount of MDA was observed (Alrashdi *et al*., 2012).

Lipid Peroxidation

The anti-lipid peroxidative studies of *J. sambac* flowers showed that which is similar to standard antioxidants, Vit-C, Vit-E, BHT and rutin. The result suggests that the methanolic extract of *J. sambac* can be used as therapeutic agents to treat against various diseases caused by free radicals and other chemical agents (Pragadheesh et *al*., 2011). The ethanol extract of *J. grandiflorum* flowers at a dose of 300 mg/kg body weight for 14 weeks to 7,12-dimethylbenz(a)anthracene (DMBA) injected animals was orally administrated, in the preinitiation period the tumor formation was completely prevented. The extract showed significant anti-lipid peroxidative effect and improved the antioxidant defense system in DMBA-treated rats. Hence it was proved that ethanol extract had potent chemopreventive efficacy (Kolanjiappan and Manoharan, 2005).

Hepatoprotective Effect

Evaluation of *Jasminum grandiflorum* for hepatoprotective activity in isoniazid induced liver damage were studied in Wistar albino rats using a dose of 200 mg/kg, orally for 30 days using ethanolic extract of *J. grandiflorum* leaves. The standard used was Silymarin (50 mg/kg). The elevated levels of alanine, aspartate, transaminase and lipid profile following isoniazid (INH)-induced hepatotoxicity administration were significantly lowered by *J. grandiflorum* treatment. Hence the hepatoprotective activity of leaves extract was proved (Dhamal *et al*., 2012).

The ethanolic, chloroform extract of *Jasminum angustifolium* Linn. Against CCl_4 induced hepatic damage in rat to study the hepatoprotective effect is assessed by the parameters such as alanine amino transferase (ALT), alkaline phosphatase (ALP), aspartate amino transferase (AST), cholesterol, total protein, bilirubin concentration and glucose in blood used to analyse the liver damage. The significant increase in the level of alkaline phosphatase (ALP), alkanine amino transferase (ALT), aspartate amino transferase (AST), cholesterol, glucose, total protein and bilirubin concentration in blood indicates Hepatic damage. The plant extracts brought back all the elevated levels of liver enzymes into normal, especially ethanolic extract showed better result than chloroform (Joshi *et al*., 2008). The ethanol and aqueous extract of *J. angustifolium* were studied for anti-tumor activity Ehrlich ascites carcinoma (EAC) induced swiss albino mice were used and were divided into five groups of 6 animals each. The antitumor effect were evaluated using the parameters such as body weight, packed cell volume, viable tumor cell count, percentage increase in life span and mean survival time. The ethanol extracts had restored the altered parameters including histological and liver enzymes to normal compared to control group in Ehrlich Ascites Carcinoma (EAC) tumor bearing mice (Asirvatham *et al*., 2012).

Cytoprotective Effect

The cytotoxic effect of methanol extracts of 19 Bangladeshi medicinal plants including *J. sambac* were tested against healthy mouse fibroblasts (NIH3T3), healthy monkey kidney (VERO) and four human cancer cell lines (gastric, AGS; colon, HT-29; and breast, MCF-7 and MDA-MB-231) using MTT colorimetric assay. The leaf extract of *J. sambac* showed significant cytotoxic activity with $IC_{50} <$ 1.0 mg/mL against at least one of the cancer cell lines tested was observed (Akter *et al*., 2014).

The silver nano particles (AgNPs) formed by *J. officinale* were characterized by transmission electron microscopy (TEM), Fourier transform infrared spectroscopy (FTIR),ultraviolet light (UV), zeta potential and X-ray diffraction (XRD). The cytotoxic activities of *J. officinale* leaves extract silver nanoparticles (JOLE-AgNPs) were measured using neutral red uptake assay (NRU) against bladder (5637) and breast cancer (MCF-7) cell lines showed high activity and can be used as a new cytotoxic alternative (Elhawary *et al*., 2020).

The Pharmacological activities were diagrammatically represented in Figure 3.

CONCLUSION

Some of these traditional and folk usages have been evaluated showing the potential medicinal use of *Jasminum* species. As it is reviewed in this paper, the antioxidant & antiaging, antiulcer, antimicrobial, anti-inflammatory, anti-acne, spasmolytic, lipid peroxidation, ACE inhibitor activity, vasodilation effect, wound healing, and protective activity of various species of *Jasminum* reported frequently. The phenolics constituents reported from jasminum were responsible for majority of the therapeutic potentials except the antimicrobial, anti-acne, spasmolytic activity and aromatherapy, which is attributed to essential oil components. The essential oils mainly contribute to fragrance and it is widely used in cosmetics and perfumery industry. The studies proved that the essential oil Linalool, is a major constituent in most of the Jasminum species and has antibacterial potential and effect on cental nervous system and the essential oils such as geranium oil, geraniol and citronellol were mainly responsible for spasmolytic activity. Hence, studies proved that the combined effect of all essential oils were the reason behind the aromatherapy, antimicrobial, anti-acne and spasmolytic effects. Rest of the pharmacological activity is correlated with antioxidant concentration and phenolic constituents in the plant extract. Among the phenolic compounds aglycones, quercetin, hespiridin, 5-Ocaffeoylquinic acid, 5-dihydrocaffeoylquinic acid, dihydro methoxy caffeoylquinic acid, 4-p-coumaroylquinic acid, quercetin-3-O-(2,6-di-rhamnosyl) glucoside, quercetin-3-O-(6-rhamnosyl) glucoside, oleacein and kaempferol-3-O-(2,6-di- rhamnosyl) glucoside were shown to possess anti-inflammation, ACE inhibition and anti-aging potentials. The free radical scavenging activities of Jasminum extract depends on concentration and increased with increasing amount of the extract. The results suggest that possess potential antiulcer actitvity, antioxidant, wound healing, vasodilation, lipid peroxidation and protective activities which may be attributed to its free radical scavenging activity and antioxidant activity of phenolics especially flavanoids.

From the above data it is clear that, although the phenolic compounds were present in negligible amount compared to terpenoids, majority of the therapeutic potential activity is attributed to phenolics. Finally, the presence of antioxidants and free radical scavengers might be the reason for importance of these plants as potent source of medicinal compounds and drugs in future.

Table 1 : Phytochemical analysis of the ethanolic Jasmine flowers extract

Compound	Result
Cardiac glycosides	+
Essential oil	+
Flavonoids	+
Saponins	+
Antioxidants	+
Coumarins	+
Steroids	+
Phenolics	+
Tannins	_
Alkaloids	_
Anthraquinones	_

Table 2 : List of compounds isolated from Jasminum

Sl No	Group	Compound
1	Terpenoids	Nerolidol, Farnesol, Phytol, citrinellylacetate, phenylethylalcohol, Nerol,geraniol, (E)-β-ocimene, 2E,6E)-farnesol,1-α-terpineol, Myrcene, cis-3-hexenyl benzoate, γ-jasmolactone, methyl linoleate, benzyl 6-O-β-Dxylopyranosyl-β-D-glucopyranoside(β primeveroside), linalyl 6-O-malonyl-β-D-glucopyranoside, Citral, Citronellol, methyl palmitate,benzyl benzoate, Jasmone, methyl anthranilate, benzyl acetate, benzyl alcohol, linalyl acetate, Linalool, (Z)-3-hexenyl benzoate, (Z)-methyl epi-jasmonoate, (E,E)-α-farnesene, Benzaldehyde, 2-phenyl ethyl acetate, geranyl acetate,benzyl salicylate, β-Pinene, δ-3-Carene, α –Pinene, (E,E)-2,4-Heptadienal, 6-Methyl-5-hepten-2-one, 2-Pentyl furan, 1-Hexanol, (E)-2-Hexen-1-ol, 1-Hexanol, (E)-2-Hexen-1-ol, 1-Hexanol, Octanal, n-Pentacosane, n-Tetracosane, Abieta-7,13-dien-3-one, n-Tricosane, n-Docosane, Abieta-8(14),13(15)-diene, Methyl octadecanoate, n-Heneicosane, Methyl linoleate, Abietadiene, Kaurene, n-Peicosane, n-Hexadecanoic acid, Methyl hexadecanoate, n-Nonadecane, (E,E)-α-Farnesyl acetate, Hexadecanal, Octadecane, Benzyl benzoate, Pentadecanal, n-Heptadecane, epi–α-Bisabolol, α-Bisabolol, Tetradecanal, Humulene epoxide II, β-Atlantol, n-Hexadecane, (E)-2-Phenyl ethyl tiglate, Caryophyllene oxide, Hexyl benzoate, (Z)-3-Hexenyl benzoate, trans-Nerolidol, Tridecanal, Benzyl tiglate, (Z,E)-α-Farnesene, Phenyl ethyl-3-methyl butanoate, (E)-β-Ionone, (E)-β-Farnesene, α-Humulene, (E)-Geranyl acetone, Aromadendrene, (E)-α-Ionone, (E)-β-Damascenone, α-Copaene, Eugenol, (E,E)-2,4-Decadienal, (E,E)-2,4-Decadienal, Undecanal, Isobornyl acetate, (E)-2-Undecenal, Isobornyl acetate, Nonanoic acid, (E)-2-Decenal, Decanal, α-Terpineol, Methyl salicylate, p-Cymen-8-ol, 4-Terpineol, Phenyl ethyl formate, p-Mentha-1,5-dien-8-ol, (E)-2-Nonenal, (E,Z)-2,6-Nonadienal, Benzyl nitrile, cis-Verbenol, cis-Limonene oxide, Nonanal, α-Campholenal, 1-Octanol, Phenylacetaldehyde, p-Cymene
2	Phenolics	Oleacein, Isoquercitrin, ursolic acid, salicylic acid, 3,4-dihydroxy benzoic acid, Eugenol, p-cresol, Hesperidin, 2-(3,4- dihydroxy phenyl)-ethanol, oleanolic acid, 5-dihydrocaffeoylquinic acid, 5-dihydromethoxycaffeoyl quinicacid, 4-p- coumaroylquinic acid, quercetin-3-O-(2,6-di-rhamnosyl)glucoside, kaempferol-3-O-(2,6-di-rhamnosyl)glucoside, Oleuropein,quercetin-3-O-(6-rhamnosyl)glucoside
3	Ester	methyl- N-methyl anthranilate, cis-3-hexenyl acetate, methyl benzoate, methyl hydroxyjasmonate
4	Fatty acid	Dotriacontanol, dotriacontanoic acid
5	Steroid	Daucosterol
6	Glycosides	Loganin, jasgranoside B, deacetyl asperulosidic acid, Aucubin, 6-O-methy- catalpol, 8-dehydroxy shanzhiside, oleoside-11-methyl ester, kaempferol-3-O-rutinoside, 7-glucosyl-11-methyl oleoside, kaempferol-3-O-alpha-L-rhamnopyranosyl (1-->3)-[alpha-L-rhamnopyranosyl (1-->6)]-beta-D-galactopyranoside, Ligstroside, 7-ketologanin, 2”-epifraxamoside, demethyl-2”-epifraxamoside.

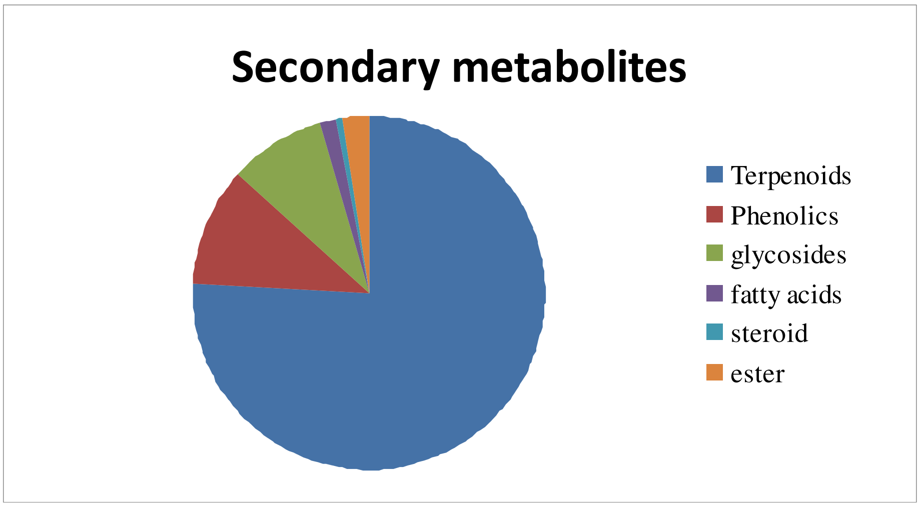
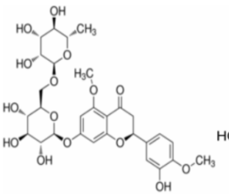


Fig. 1 : Secondary metabolites in Jasminum



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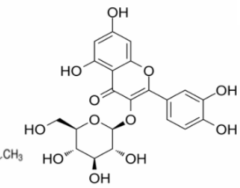

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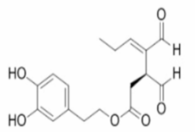

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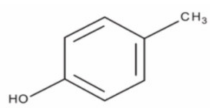

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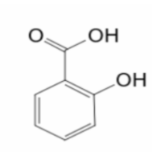

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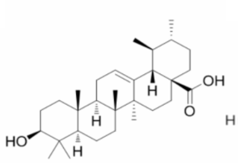

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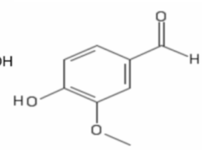

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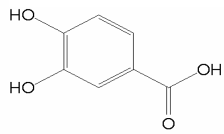

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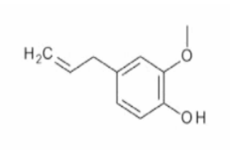

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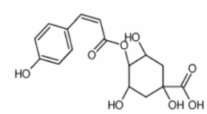

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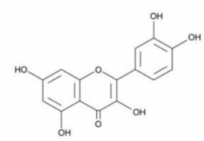

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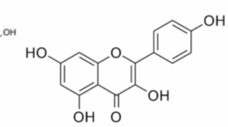

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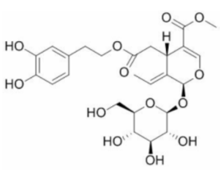

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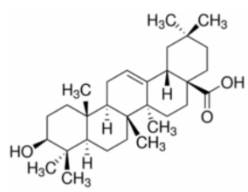

(14)

Fig/ 2: structure of some phenolic compounds contained in *Jasminum*sps.; (1) Hesperidin (2) Isoquercitrin (3) Oleacein (4) p-cresol (5) Salicylic acid (6) Ursolic acid (7) Vanilin (8) 3,4-dihydroxybenzoic acid (9) Eugenol (10) 4-p-coumaroylquinic acid (11) Quercetin (12) Kaemferol (13) Oleuropein (14) Oleanolic acid

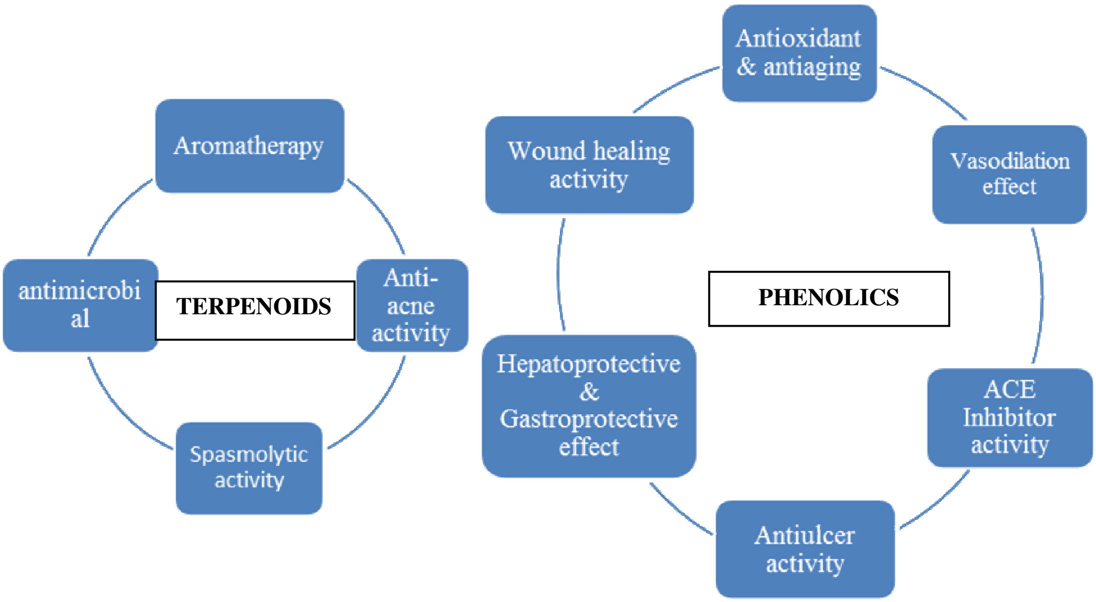

Fig. 3 : Pharmacological activities of Terpenoids & Phenolics

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