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A Review on *Eucalyptus globulus*: A New Perspective in Therapeutics

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Abstract

Eucalyptus globulus is a shrubby plant or a flowering tree belonging to the family Myrtaceae. Genus eucalyptus is known to contain more than 700 species and has widely been used for various purposes since thousands of years in the history of mankind. Eucalyptus is basically native to Tunisia and Australia but has also been evident to be found in Africa and from tropical to southern temperate regions of America. Genus eucalyptus further consists of four subspecies which are *Eucalyptus bicostata*, *Eucalyptus pseudoglobulus*, *Eucalyptus globulus* and *Eucalyptus maidenii* among which *Eucalyptus globulus* is a medium to large sized evergreen and broadleaf tree that can grow upto the height of 70 m and its diameter can be about 4 to 7 feet. Different parts of this plant are nutritionally very important and therapeutically highly valuable due to specific chemical composition as its essential oil contain esters, ethers, carboxylic acids, ketones, aldehydes, alcohols and hydrocarbons along with monoterpenes and sesquiterpenes. Phytochemical analysis of this plant has revealed that leaf oil contain 1,8-cineole, α-pinene, p-cymene, cryptone and spathulenol. In contrast, essential oil extracted from buds, branches and fruits constitutes α-thujene, 1,8-cineole and aromadendrene as major components. Due to these chemical compounds, *Eucalyptus glabrous* is found to be a potential anti-microbial, anti-fungal, anti-viral, anti-inflammatory, analgesic, anti-nociceptive and anti-oxidant agent of nature. Some recent scientific investigations have also revealed that essential oil of *Eucalyptus glabrous* also have anti-diabatic potentials that enhances its market value due to excessive usage in number of pharmaceutical products of traditional and advanced system of medicines.

Key words: *Eucalyptus globulus*, 1,8-cineole, α-pinene, p-cymene, cryptone, spathulenol, anti-microbial, anti-fungal, anti-viral, anti-inflammatory, anti-nociceptive, anti-oxidant

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1. Introduction

Eucalyptus globulus is a flowering tree that belongs to myrtle family (Myrtaceae). It has been used for thousands of years throughout human history. The genus eucalyptus contains more than 700 species and varieties and they have been successfully introduced worldwide. Eucalyptus is native to Australia and Tasmania and also in Africa and tropical to southern temperate America [1]. Variability is prevalent in morphology, growth habit, flower colour, leaves, stems and chemical composition. In case of *Eucalyptus globulus*, pollen competition favors cross-pollination over self-pollination. Controlled pollinations with self-pollen, cross-pollen and a mixture of self-pollen and cross-pollen were conducted on three partially self-incompatible trees. Paternity of individual seeds resulting from mixed pollination was determined by isozyme analysis. No evidence for pollen competition was found. Instead, seed paternity reflected the level of self-incompatibility of each trees as determined by separate self-pollinations and cross-pollinations. Furthermore, number of seeds set per capsule following mixed pollination was significantly less than that of following cross-pollination in the two least self-compatible trees. These results suggest that both self-pollen and cross-pollen tubes reach ovules following mixed pollination and that of a late-acting self-incompatibility mechanism operates to abort a certain proportion of self-penetrated ovules [2].

The flowers of *Eucalyptus globulus* are mainly pollinated by insects but birds and small mammals may also act as pollinating agents [3]. *Eucalyptus globulus* is known by different names depending upon where you are in the world and its common name is "Australian Fever Tree", "Tasmania Blue Gum", "Southern Blue Gum" or "Blue Gum", "Blue Gum Tree" and "Stringy Bark". In Arabic language, it is known as "ban" or "kafur". In Burmese language it is known by "pyilon-chantha". The trade name of *Eucalyptus globulus* is "blue gum". In Amharic language it is called "nech bahir zaf". In English language, it is commonly known as "turpentine gas", "Tasmanian blue gum eucalypt", "Tasmanian blue gum", "southern blue gum", "fever tree", "blue gum eucalyptus" and "blue gum". In Japanese language, it is called "yukari-no-ki". In Spanish language, it is known as "eucalipto". In Swahili it is known as "mkaratusi" and in Tigrigna language it is called "tsaeda-kelamitos" [4].

Eucalyptus globulus is a complex species as consist of four further subspecies which are *Eucalyptus bicostata, Eucalyptus pseudoglobulus, Eucalyptus globulus* and *Eucalyptus maidenii*. The only one variety of *eucalyptus globulus* is *Eucalyptus globulus* var. compacta Labill-Dwarf blue gum [5]. Eucalyptus oil has numerous traditional uses especially in non-prescription pharmaceuticals but the market is small. Currently somewhere between three and five thousand tonnes are traded each year on international markets, with only two or three hundred tonnes being produced by Australia. Eucalyptus oil based products have been used as a traditional non-ingestive treatment for coughs and colds [6].

2. Demography/Location

Eucalyptus globulus can be grown in variety of climatic conditions and environmental modifications but the best known optimum conditions are evident to be found in countries having warmer climate. Eucalyptus is preferably found in Albania, Tunisia, Argentina, Bangladesh, Cambodia, Brunei, Eritrea, Greece, Ethiopia, Indonesia, Italy, Israel, Laos, Kenya, Malaysia, Myanmar, Morocco, Namibia, Nigeria, Nepal, Pakistan, Spain, Philippines, Sudan, Uganda, Tanzania, Thailand, Malta and United Kingdom [7]. Australia is covered by 92,000,000 hectares that is equivalent to 227,336,951 acres of *Eucalyptus globulus* forest thereby comprising three quarters of the whole area covered by native forests. Similarly, total area of *Eucalyptus globulus* that is planted in India is supposed to be exceeding 2,500,000 ha [8]. The "Tasmanian Blue Gum", "Southern Blue Gum" or "Blue Gum" are the other names for *Eucalyptus glabrous* and is the most widely cultivated plant so far [9]. In the year 2006, it comprised about 65 percent of all plantation hardwood in Australia with about 4,500 km planted area. *Eucalyptus globulus* is the primary source for eucalyptus oil production all around the world. During the last ten years, in the northwestern regions of Uruguay, *Eucalyptus globulus* was one of the major cultivated crop [10]. That zone has a potential forested area of 1,000,000 hectares, approximately 29% of the national territory dedicated to forestry among which approximately 800,000 hectares are currently forested by monoculture of *Eucalyptus globulus*. In Brazil, there are around 7 million hectares planted area that can produce upto 100 cubic metres per hectare per year.

3. Botanical Specifications

Eucalyptus glabrous is a broadleaf evergreen plant that can attain the maximum height of about 70 m as evident to found in Europe [11]. Although more than 700 different species of this plant are found to exist but *Eucalyptus glabrous* is the most widespread among all other species in East Bay [12]. It is an aromatic plant that has straight trunk and well-developed crown with tap root system exceeding the depth of 10 feet [13]. The most readily recognizable characteristics of eucalyptus species are the distinctive flowers and fruit (capsules or gum nuts). Flowers have numerous fluffy stamens which may be white, cream, yellow, pink or red in colour. In bud, the stamens are enclosed in a cap known as an operculum which is composed of the fused sepals or petals or both. Thus flowers have no petals, but instead decorate themselves with many showy stamens. As the stamens expand, operculum is forced off, splitting away from the cup-like base of the flower; this is one of the features that unite the genus [14]. The appearances of eucalyptus bark varies with the age of the plant, the manner of the bark shed, the length of the bark fibers, the degree of furrowing, the thickness, the hardness and the colour.

All mature trees put on an annual layer of bark, which contributes to the increasing diameter of the stems. Bark consist of long fibers and can be pulled off in long pieces, is hard rough and deeply furrowed, bark is broken up into many distinct flakes, has short fibers, this has the bark coming off in long thin pieces but still loosely attached in some places. The bark of tree is hard, rough and deeply furrowed. It is soaked with dried sap exuded by the tree which gives it a dark red or black coloration. The fruit looks like cone shaped woody capsules called "gum nuts", distinctive for the genus and fruiting period is autumn and winter. The seed morphology of *Eucalyptus globulus* is extremely variable. Shape, size, colour and surface ornamentation are strongly inherited traits and indicative of taxonomic groups. The primitive cotyledon shape is reniform and this form of cotyledon occurs widely in the genus. The extreme modification is the bisected cotyledon formed by emargination, resulting in a Y-shaped structure. A large number of species have cotyledons shaped between these extremes and are usually described as bilobed, although the distinction between the bilobed and the reniform is often blurred [15].

Eucalyptus globulus also grows in mild, warm and tropical climates having mean annual temperature ranging from 3-22 to 21-40°C, but cannot live at temperatures lower than -5°C and mean annual rainfall ranging from 250 to 2500 mm. *Eucalyptus globulus* are cultivated in Mediterranean area and grow until 350 meters over the sea level. Usually the young plants are planted in spring or at the end of summer. *Eucalyptus globulus* should be grown in climate with high humidity otherwise suffers burning of leaf border. It can grow in wide range of soils and with limited water supply. The soil type grows best on deep, silty or loamy soils with a clay base and accessible water table. It is one of the species found to be most tolerated to acid soils and soils optimum pH ranges from 5.5 to 6.5. In India, location was 10.2572°N latitude; 78.8861°E longitude; 216 ft above sea level with average temperatures ranging between 33.5°-42.2°C and 1043.31 mm annual rainfall. The soil type of the study area is red soil [16].

4. Chemistry

Eucalyptus globulus has a fresh mint like smell and a spicy, cooling taste and has various concentrations of minerals. Eucalyptus is naturally occurring cellulose or protein, while synthetic fibers are not found and identification of lipid constituents showed that this plant contains cutin and soluble lipids. Eucalyptus essential oil is colorless and has a distinctive taste and odor and typical volatility. Essential oil of eucalyptus is highly flammable and contains compounds that are natural disinfectants and pest deterrents.

4.1 Chemical Composition

Essential oil of *Eucalyptus glabrous* is composed of mixtures of volatile organic compounds including hydrocarbons, alcohols, aldehydes, ketones, acids, ethers and esters. Most of the components are monoterpenes and sesquiterpenes in nature which consist of two or more isoprene (C_5H_8) units. Essential oil has various concentrations of calcium, nitrogen, phosphorus, iron, manganese, zinc, boron and copper.

4.2 Phytochemistry

The essential oils obtained from the leaves, bare branches, flower buds and mature fruits of *Eucalyptus globulus* contain large number of highly valuable chemical compounds. The leaf oils were found to contain 1,8-cineole (4.10–50.30%) depending upon maturity and origin of their collection site. Other major components of the leaf oils were α-pinene (0.05–17.85%), p-cymene (trace-27.22%), cryptone (0.00–17.80%) and spathulenol (0.12–17.00%). In contrast, the essential oil of fruit, bud and branch oils is known to contain α-thujene (0.00%, 11.95% and trace respectively), 1,8-cineole (15.31%, 36.95% and 56.96% respectively) and aromadendrene (23.33%, 16.57% and 8.24% respectively).

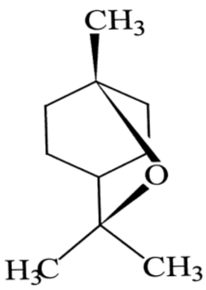

Fig 1 Chemical structure of 1,8-cineole

5. Postharvest Management and Long Term Storage

Cut green leaves are an important component of the floricultural industry as they are largely used for decoration as filler in floral compositions. They provide freshness and colour variety to arrangements and bouquets. Cut eucalyptus is especially important for preparing arrangements of flowers that are naturally without leaves, such as gerberas and orchids. In many countries of the north Europe, in particular the UK, cut greens can be used for indoor decorations during winter time, providing a striking contrast to the wintry outdoor landscape. The increase of economic importance of cut foliage production in the Italian ornamental industry is a result of the reorganization of the internal production in response to a crisis period in the cut flower production. Worldwide flower market has been becoming stronger and stronger for the flowers coming from the developing countries such as Colombia and Kenya etc., which can produce flowers at lower costs. Moreover, the globalization of the flower market led Italian growers to seek for alternative crops such as cut foliage. In addition, consumers are paying more attention to the appearance of floral compositions and foliage is now almost as an important design element as the flowers themselves.

The Italian area for cut foliage production was 1542 ha in 2005, with a total production of 1.3 million units with 85% of this cultivation realized in plain area, and the regions principally involved were liguria (58%), campania (8.56%) and tuscany (6.34%). Vase life of *Eucalyptus globulus* during May to June is below 10 days. Cut eucalyptus branches like other cut foliage, during postharvest life undergo many physiological changes that may induce several disorders leading them to die. The senescence studies carried out on cut flowers and foliage have greatly helped to find technological strategies to prolong vase life of cut eucalyptus foliage. The quality and the vase life of cut eucalyptus foliage essentially depend on leaf health status. Senescence symptoms of cut eucalyptus foliage can be leaf wilting, desiccation, rolling and necrosis. However, the postharvest life of cut eucalyptus foliage depends on many internal and external factors, which may act synergistically reducing the vase life. Therefore it is difficult to identify the major physiological disorder that limits the postharvest life. The intensity of leaf colour is closely correlated with the quality of ornamental cut foliage. The concentration of chlorophyll is directly correlated with consumer's attractiveness.

In the floriculture industry, the use of chlorophyll meter may be useful for estimating the quality of cut greens. Comparison studies on chlorophyll measurements in *Eucalyptus globulus* were performed using no invasive method (SPAD) or analytical determination. Results were not satisfactory and for this species SPAD values are not an indicator of leaf senescence. Cut foliage show chlorophyll degradation when they are already senescent, therefore the chlorophyll content cannot be used as marker for evaluating the quality of cut *Eucalyptus globulus* branches. The main postharvest problem of cut eucalyptus is the weight loss and reduced water uptake. Since the cut eucalyptus such as all cut greens are sold by weight and any reduction is directly translated in economic losses. The ethylene is another important parameter that may affect the vase life of many cut flowers and foliage. The ethylene production of cut eucalyptus varies with the stage of leaf maturity. Cut immature branches have higher ethylene production compared to mature branches. In cut *Eucalyptus globulus*, immature branches produce 6 nl $h^{-1}g^{-1}$ FW while the mature branches produce half amount of ethylene about 3 nl $h^{-1}g^{-1}$ FW.

Analogous results were found in immature and mature branches of *Eucalyptus globulus* [17]. However, ethylene production varies also from species to species. In cut *Eucalyptus globulus* branches, the amount of ethylene ranges from 4 to 11 nl $h^{-1}g^{-1}$ FW during the first 24 hours after harvest while the ethylene production in *Eucalyptus cinerea* ranges from 2-3 nl $h^{-1}g^{-1}$ FW. Cut eucalyptus species can be considered as ethylene insensitive because exogenous applications of ethylene induced visible damage at 20 μL L^{-1} thereby reducing the vase life by 19% compared to control. Since the ethylene concentration during the distribution chain or at retailer markets does not overcome 3 μL L^{-1}, the cut eucalyptus foliage can be reasonably considered ethylene insensitive. Different behaviour was observed when cut eucalyptus was treated with 1 mM 1-aminocyclopropane-1-carboxylic acid the ethylene precursor. Treatment ACC strongly reduced the vase life and induced complete leaf abscission. Ethylene production and respiration trends were opposite during vase life and eucalyptus cannot be ascribed to climateric or no climateric pattern [18].

Environmental conditions during storage and transportation are extremely important for preserving quality of ornamental perishables. Floriculture items have to be often transported for long distances before they reach the selling markets and are highly susceptible to quality losses. The packaging systems play an important role in preventing water losses, product damage and reducing transportation costs. The optimal environmental conditions for cut foliage are low temperatures and high relative humidity in order to minimize water losses. Temperature should be as low as possible considering the freezing point of species. However, the common storage and transportation temperature ranges from 0 to 5°C. Low temperatures reduce all physiological processes, especially respiration and ethylene production. Temperatures close to 0°C should be preferred for long shipping distance, while higher temperatures around 5°C may be used for local commercialization. Like many essential oils, eucalyptus oil should be store in a dark glass bottle and kept in a cool place out of direct sunlight. Unlike many essential oils, eucalyptus oil is quite robust and if stored correctly, will keep well for 1 to 2 years from the date of production [19].

Dry storage is not advisable in these species, because the high transpiration surface of cut foliage induces a rapid water loss and subsequent wilting. Recent studies on *Eucalyptus parvifolia* showed that cut branches can be dry stored if sealed in plastic bags and kept at 4°C. Optimal results were obtained when a mild vacuum was applied to seal bags reducing volume. In these experiments, air inside the bags was reduced but not completely removed. Cut eucalyptus branches are dry stored in plastic bags under mild vacuum conditions that can be stored until 6 days without any negative effect on subsequent vase life. This period of time may be enough for the most common transport destinations. The maximum vacuum storage duration depends on the development stages at harvesting of *Eucalyptus parvifolia*. In fact, immature cut branches can be stored only for 3 days. Vacuum storage is a common practice for preserving vegetables and fruits. In vacuum, storage bags or in storage chambers equipped with controlled atmosphere the gas concentration continuously changes, due to plant tissue respiration thereby generating a passive modified atmosphere.

The most important advantage of vacuum packaging applied to the cut foliage industry is the increase of loading capacity per unit of volume, reducing the transportation costs without compromising the produced quality. Wet storage of cut foliage, instead is the most used method at the selling point or in farm before transportation. Cut *Eucalyptus globulus* was satisfactorily stored and cut *Eucalyptus globulus* for 4 weeks without affecting the postharvest life. The extraction yields of essential oils of the stems, adult leaves, fruits and immature flowers of *Eucalyptus globulus* were 0.52%, 0.45%, 1.12% and 0.53% respectively. Yields of essential oil from *Eucalyptus globulus* leaves from southern Tunisia collected in October 2007 was richer than our adult leaves harvested in March 2007, with a variation of 4.45%. *Eucalyptus globulus* from the center of Tunisia was richer in the essential oil than that of south with a difference of 2.25%. The yield variability in the total essential oil of *Eucalyptus globulus* species growing in Tunisia can be attributed to the soil conditions and ecological, climatic conditions, age of plant and the season of harvesting [18]. There are three major commercialized products of eucalyptus: piperitone type industrial product, citronellal type perfumery products and cineole rich medicinal products [20].

6. Conventional Uses and Medicinal Applications

The uses of eucalyptus oils are very vast and wide-ranging because there are so many species. Traditionally, eucalyptus species have been used for supporting a healthy respiratory system and to soothe the muscles after exercise. The Australian Aborigines used the leaves for soothing physical and emotional discomfort. Unfortunately with the broad uses and abundance of species some confusions, are faced and even exploitation of the consumer takes place. This is similar to the problems often encountered with other popular essential oils such as cinnamon essential oil and the Melaleuca species. Therefore, it is upto us as consumers and oil users to have an understanding of the plant and the oil so we can use the oils safely and correctly.

6.1 General Uses

Uses of *Eucalyptus globulus* essential oil, distilled from the Australian native *Eucalyptus globulus* tree, boast a long list of traditional uses. Aboriginal Australians used *Eucalyptus globulus* to heal wounds, cure fungal infections and as a fever reducer. Chinese, Greek, European and Ayurvedic medicine later adopted *Eucalyptus globulus* as a disinfectant and expectorant. Present day medicinal applications of *Eucalyptus globulus* oil may be seen in the majority of grocery stores and pharmacies around the world including the oil's use in vapor chest rubs, over-the-counter cough and cold medications, sore throat sprays, topical pain relievers just to name a few.

6.2 Pharmacological Uses

Eucalyptus globulus oil is used as an anti-septic and anti-spasmodic stimulant agent in bronchitis, asthma and minor respiratory complaints [21]. By using externally, it has increasing effects on blood flow and skin temperature. Therefore, it has been used in semi-solid dosage forms for the treatment of cough, to promote scar formation in burns and injuries and as an anti-rheumatic agent. It is used as an inhalant because 1,8-cineole is a well-known medicinal component that causes a sensation of cold and this is accompanied with a facilitated respiration [22]. Thus it is often inhaled in asthma, pharyngitis and related conditions [23].

6.2.1 Anti-Microbial Activity

In comparison, crude *Eucalyptus globulus* oil seems to be more efficient against micro-organisms grown in suspensions and biofilms compared with pure 1,8-cineole [24]. The 1,8-cineole was an active against two gram-positive bacteria while it was inactive against the gram-negative bacteria *Escherichia coli* and *Pseudomonas aeruginosa* and also showed a positive effect against *Escherichia coli*.

6.2.2 Anti-Fungal Activity

Eucalyptus globulus oil was found effective against twelve yeast-like fungi and filamentous fungi. MICs values between 0.025 and 1% (V/V) were found [25]. The 30 plant's oils for anti-candida activity were tested against two different strains of *Candida albicans*. A concentration of 0.05% (V/V) was enough to inhibit their growth completely, MIC values of 2-8 mg/ml. Anti-fungal effects of *Eucalyptus globulus* oil were also observed against five Fusarium species.

6.2.3 Anti-Viral Activity

The potential anti-viral effect of *Eucalyptus globulus* oil was determined against Herpes simplex virus type I (HSV-1) [26]. HSV-1 was incubated with various concentrations of *Eucalyptus globulus* oil for one hour at room temperature. The IC50 could be given with 55µg/ml. At maximum non-cytotoxic concentration (200 µg/ml = ~0.02%) plaque formation was significantly reduced 3 days after cell infection by >96% after pre-incubation of HSV-1 and essential oil compared with untreated control. Only moderate activity was seen when the essential oil was added to host cells prior or after infection. Some scientists demonstrated that *Eucalyptus globulus* oil (0.01%) reduced virus titers by 58-75% for HSV-1 and HSV-2. It could be shown that pre-treatment of virus with the essential oil showed best results while pre-incubation of the cells did not reduce virus production. The anti-viral activity of *Eucalyptus globulus* essential oil on strains of adenovirus and mumps virus isolated from patients. In a concentration of 0.25 µl/ml (0.025%), the essential oil showed a mild anti-viral activity (~40%) against mumps virus, but nor against adenovirus. The potential anti-viral effect of 1,8-cineole was determined against Herpes simplex virus type I (HSV1). The IC50 could be given with 1200 µg/ml. The potential anti-viral effect of α-pinene was determined against Herpes simplex virus type I (HSV-1) in-vitro. The IC50 could be given with 4.5µg/ml [27].

6.2.4 Anti-Inflammatory Activities

Anti-inflammatory effect of *Eucalyptus globulus* oil in the paw oedema test in rats after subcutaneous injection in a dosage of 100 mg/kg (HED=16 mg/kg) [25]. *Eucalyptus globulus* oil to rats p.o. in a dosage of 12 mg/kg/day for 15 days (HED=1.9 mg/kg) to test whether *Eucalyptus globulus* oil treatment could induce a recovery of peripheral blood mononuclear cells activity after bone marrow suppression (by 5-fluorouracil on day 7). In the sets of experiment, blood was collected on day 0, 7, 15 and 20. At day 15, an increase of circulating monocytes and an increment in the phagocytic activity of granulocytes and monocytes were recorded for immuno-competent rats. In immuno-suppressed rats, a recovery of the percentage of circulating granulocytes was observed as well as a nearly restored phagocytic activity of peripheral blood granulocytes/monocytes [28]. *Eucalyptus globulus* oil (~73 and 146 µg/ml) increased the phagocytic activity of human monocyte derived macrophages after 24 h treatment, while the release of immune-modulating cytokines (IL-2, IL-4, IL-6, IL-10, TNF-α, INF-γ) was not influenced. In order to prove the ability to reduce cytokine release, scientists confirmed an anti-inflammatory effect of *Eucalyptus globulus* oil in ex-vivo cultured and stimulated alveolar macrophages from patients with chronic obstructive pulmonary disease (COPD). Reduction of TNF-α release from LPS stimulated macrophages was observed with ~1 µg *Eucalyptus globulus* oil/ml. The 1,8-cineole patients and healthy subjects were given 3×200 mg, 1.8-cineole per day for 3 days, blood samples were taken and monocytes isolated. Production of LTB4 and PGE2, both metabolites of the arachidonic acid pathways, from isolated blood monocytes, which were stimulated with A23187 ex-vivo was studied. Spontaneous LTB4 and PGE2-production in patients with treated bronchial asthma was lower than in healthy volunteers. After 3 days of treatment, LTB4 and PGE2-production in isolated, activated blood monocytes were significantly suppressed in both groups. It was postulated that 1,8-cineole reveals a useful anti-inflammatory activity [25]. An inhibition of cytokine production in-vitro by 1,8-cineole has also been found. Cell cultures of lymphocytes and monocytes from 9 volunteers, who donated their venous blood, were stimulated and treated with 1,8-cineole (10-9-10-5 M).

6.2.5 Analgesic/Anti-Nociceptive Activity

Eucalyptus globulus oil induced analgesic effects. Analgesic effect was demonstrated by i.p. injection at doses of 10 or 100 mg/kg (rats, positive control: morphine; HED=1.6 and 16 mg/kg) and by subcutaneous injection at doses of 0.1, 10 and 100 mg/kg (acetic acid induced writhing mice; HED=0.16, 1.6 and 16 mg/kg). The effect of 1,8-cineole (oral administration) in mice on chemical (acetic acid and formalin) nociception. In the formalin test, a dosage of 400 mg/kg (HED=32.5 mg/kg) inhibited significantly the paw licking response while a dosage of 200 mg/kg (HED=16.2 mg/kg) inhibited only the second phase. The incidence of abdominal constriction response was found to be significantly less even in the lowest dose of 100 mg/kg (HED=8.1 mg/kg). Anti-nociceptive effects of 1,8-cineole was examined in rats and mice (tail-flick, hot plate). A dosage of 0.3 mg 1,8-cineole/kg in rats (i.p.) provoked a significant effect on reaction time to nociceptive effects in rats, while changes in reaction in mice, could not be seen. The β-pinene in-vivo studies: anti-nociceptive effects of β-pinene were examined in rats and mice (tail-flick, hot plate). The β-pinene provoked a supra spinal anti-nociceptive action in rats only (0.3 mg/kg, i.p.).

6.2.6 Anti-Oxidant Activities

Anti-oxidant properties of essential oils are well known and in order to prove the ability of essential oils to reduce reactive oxygen species (ROS) production even confirmed an anti-oxidant effect of eucalyptus oil (1 µg/ml) cultured and stimulated alveolar macrophages from patients with chronic obstructive pulmonary disease (COPD). But the exact mechanism on how essential oils exert this function on inflammatory cells is still unknown. Whether this effect correlates with clinical measurable benefits for the patients has also to be studied.

6.2.7 Anti-Diabetic and Repellent Effects

Anti-diabetic effects and repellent effects have been reported for *Eucalyptus globulus* oil.

7. Summary

Eucalyptus is large genus of mostly very large trees of the myrtle family (Myrtaceae), native to Australia, Tasmania and nearby islands. More than 500 species have been described. In Australia, the eucalypti are commonly known as "gum trees" or "stringy bark trees". Many species are cultivated widely throughout the temperate regions of the world as shade trees or in forestry plantations. Economically, eucalyptus trees constitute the most valuable group within the order Myrtales. The leaves are leathery and hang obliquely or vertically. The flower petals cohere to form a cap when the flower expands. The fruit is surrounded by a woody, cup-shaped receptacle and contains numerous minute seeds. Possibly, largest fruits ranges from 5 to 6 centimetres (2 to 2.5 inches) in diameter are borne by *Eucalyptus globulus,* also known as the mottlecah or silver leaf, eucalyptus. The eucalypti grow rapidly and many species attain great height. *Eucalyptus globulus* the giant gum tree or mountain ash of Victoria and Tasmania, attains a height of about 90 metres (300 feet) and a circumference of 7.5 m. Eucalyptus wood is extensively used in Australia as fuel and the timber is commonly used in buildings and fencing.

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