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*Matricaria*genus as a source of antimicrobial agents: From farm to pharmacy and food applications

Mehdi Sharifi-Rad[a], Jolanta Nazaruk[b], Letizia Polito[c], Maria Flaviana Bezerra Morais-Braga[d], Janaína Esmeraldo Rocha[d], Henrique Douglas Melo Coutinho[d], Bahare Salehi[e,f,**], Giulia Tabanelli[g], Chiara Montanari[g], María del Mar Contreras[h], Zubaida Yousaf[i], William N. Setzer[j], Deepa R. Verma[k], Miquel Martorell[l,***], Antoni Sureda[m], Javad Sharifi-Rad[n,o,*]

[a] *Department of Medical Parasitology, Zabol University of Medical Sciences, Zabol, 61663-335, Iran*
[b] *Department of Pharmacognosy, Medical University of Bialystok, Mickiewicza 2a, 15-089, Bialystok, Poland*
[c] *Department of Experimental, Diagnostic and Specialty Medicine-DIMES, General Pathology Unit, Alma Mater Studiorum, University of Bologna, Via San Giacomo 14, 40126, Bologna, Italy*
[d] *Laboratory of Microbiology and Molecular Biology, Department of Biological Chemistry, Universidade Regional do Cariri – URCA, Crato, CE, Brazil*
[e] *Medical Ethics and Law Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[f] *Student Research Committee, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[g] *Centro Interdipartimentale di Ricerca Industriale Agroalimentare, Università degli Studi di Bologna, Cesena, Italy*
[h] *Departamento de Ingeniería Química, Ambiental y de los Materiales, Universidad de Jaén, Spain*
[i] *Department of Botany, Lahore College for Women University, Jail Road Lahore, Pakistan*
[j] *Department of Chemistry, University of Alabama in Huntsville, Huntsville, AL, 35899, USA*
[k] *Department of Botany & Postgraduate Department, Biological Sciences, VIVA College of Arts, Science & Commerce, Virar (w), 401303, Maharashtra, India*
[l] *Department of Nutrition and Dietetics, Faculty of Pharmacy, University of Concepcion, Concepcion, Chile*
[m] *Research Group on Community Nutrition and Oxidative Stress, Laboratory of Physical Activity Sciences, and CIBEROBN – Physiopathology of Obesity and Nutrition, CB12/03/30038, University of Balearic Islands, Palma de Mallorca, Spain*
[n] *Phytochemistry Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[o] *Department of Chemistry, Richardson College for the Environmental Science Complex, The University of Winnipeg, Winnipeg, Canada*

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ABSTRACT

Matricaria is a widespread genus of flowering plants of the family Asteraceae that grow in temperate regions of Europe, Asia, America and Africa. Some of the species are also naturalized in Australia. Some species of this genus such as Chamomiles are recognized medicinal plants and cultivated in several countries for commercial purposes: to obtain its blue essence, as herbal tea, and for pharmaceutical or cosmeceutical uses. The phytochemical composition of *Matricaria* spp. includes volatile terpenoids (*e.g.*, α-bisabolol, bisabolol oxide A and B, β-trans-farnesene and chamazulene), sesquiterpene lactones such as matricin, and phenolic compounds (flavonoids, coumarins and phenolic acids). Their essential oil is obtained from the fresh or dried inflorescences by steam distillation, and additionally cohobation of the remaining water. The volatile composition of the essential oil, especially the content of the valuable components α-bisabolol and chamazulene, depends on the plant part, origin and quality of the source, genetic, and environmental factors. Moreover, other parameters, such as season of harvest and methods of extraction, can affect the extraction yield of the essential oils/extracts, their composition and, therefore, their bioactivity. Due to the importance of this genus and particularly *M. recutita* (*M. chamomilla*), this review focus on its cultivation, factor affecting essential oils' composition and their role in traditional medicine, as antibacterial agents and finally as food preservatives.

* Corresponding author at: Phytochemistry Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran and Department of Chemistry, Richardson College for the Environmental Science Complex, The University of Winnipeg, Winnipeg, Canada.
** Corresponding author at: Medical Ethics and Law Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran and Student Research Committee, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
*** Corresponding author at: Department of Nutrition and Dietetics, Faculty of Pharmacy, University of Concepcion, Concepcion, Chile.
E-mail addresses: bahar.salehi@sbmu.ac.ir, bahar.salehi007@gmail.com (B. Salehi), mmartorell@udec.cl (M. Martorell), javad.sharifirad@sbmu.ac.ir, javad.sharifirad@gmail.com (J. Sharifi-Rad).

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1. Introduction

Matricaria is a genus of flowering plants and falls under the same family as common species such as sunflower (*Helianthus annuus*), lettuce (*Lactuca sativa*), and artichoke (*Cynara scolymus*), *i.e.*, Asteraceae. Most of the species of this genus are commonly found in temperate regions of Europe, Asia and America, and also in northern and southern Africa (Bremer and Humphries, 1993; Singh et al., 2011; Miraj and Alesaeidi, 2016). Some of the species are naturalized in Australia. They are annual aromatic herbs that can be found growing on lands rich in nutrients as well as on roadside.

These genus are much branched and these many branched stems are prostrate to erect, glabrous, and leafy (Bremer and Humphries, 1993; Singh et al., 2011). Flowers are radially symmetrical, heads solitary, either heterogamous with white ray florets female flowers (*M. recutita*, also known as *M. chamomilla*) or homogamous and lacking ray florets (*M. discoidea*). The leaves are 2–3 pinnatisect and repeatedly divided into segments which are narrowly linear. Receptacle is conical, hollow and lacks receptacular scales. Achenes are obovoid and somewhat laterally flattened, obliquely truncate above, inconspicuously 3–5 ribbed on the posterior face and without oil glands on the anterior side. The pappus may be crown shaped and short or lacking.

Genus *Matricaria* comprises plants with various secondary metabolites of varied chemical nature. A number of chemical components have been isolated from genus *Matricaria* (Kazemi, 2014). A majority of the chemical constituents have been recorded mainly in *Matricaria chamomilla* also called as German chamomile. Plants belonging to this genus have shown the presence of components like volatile compounds, sesquiterpene lactones, and phenolic compounds such as flavonoids (flavones and flavonols) and coumarins (Table 1).

2. Cultivation of plants from the genus *Matricaria*

The chamomile genus *Matricaria* is one of the most important and well-known herbal drugs. Chamomiles are grown commercially in Europe, North Caucasus to South Siberia, the intercontinental state Turkey, Asia (Afghanistan, Pakistan, North India, and Japan), North Africa (Egypt, Ethiopia), North and South America (east coast of the USA, Cuba, Argentina, and Brazil) and New Zealand (Singh et al., 2011). It is cultivated mostly for its blue essence, as herbal tea, and in view of its ever-increasing usage in pharmaceutical, cosmetic and sanitary, perfumery industry, and production of nutritional flavors (Mohammad, 2011). This important medicinal plant has been cultivated from two chamomiles: Roman chamomile, *Chamamelum nobile* L., with ancient name *Antemis nobilis* and German chamomile, *Matricaria recutita* (*M. chamomilla*).

German chamomile requires cool, temperate conditions to grow well, with temperature ranging from 7 to 26 °C. German chamomile can survive cold winter nights as low as −12 °C (Singh et al., 2011). Although chamomile is drought tolerant, it needs enough water to germinate and for the development of the young plants. German chamomile requires no extra water once properly established. An annual precipitation of 400 to 1400 mm per season is enough to produce a good crop. German chamomile can be grown on a wide range of soil types, but prefers a well-drained, sandy or sandy-loam soil with a pH of 4–8 grows in any other soils that have good drainage. Each plant normally produces from 12 to 14 sets of runners. Make sure plants with superior qualities are used for vegetative propagation. Spacing of plants should be 30 × 30 cm (Dutta and Singh, 1964). German chamomile does not require large quantities of fertilizers, but depending on soil tests, small quantities of nitrogen, phosphorus, and potassium should be applied before planting. Sprinkler irrigation should be used. Constant weeding is necessary until the chamomile 'mat' takes over. Whiteflies, aphids, spider mites, and thrips are the major insect pests affecting chamomile. Flower heads are harvested in the summer while in full bloom (Bremer and Humphries, 1993; Singh et al., 2011).

According to most of reports, the ideal temperature to dry the flowers is 35–38 °C and the necessary time to do this is 36–72 h. Alternatively, this temperature in electric driers is 40–60 °C. By manual harvesting, production of fresh flowers is 2 tons per hectare. This resulted in 100–500 kg dried product. In mechanized harvest, 400–800 kg hectare flowering stem would be collected to produce the essence. Early or late harvest would bring about quality reduction of effective materials. The flowers have maximum amounts of essence when ray florets are fully bloomed. The flowers should be dried immediately after the harvesting. Any delay can bring changes in flowers color and reduction of their essence quantity (Anderson et al., 1996; Fontanarosa, 2000).

While somewhere in India this crop is of 4–6 months and propagated by seeds either by transplanting or direct sowing. Since it is a Rabi crop it is sown on second fortnight of December in North Indian hills, while in plains it is sown in late September. Crop requires 20–25 tons of farmyard manure (Nidagundi and Hegde, 2007). Flowers can be used fresh, frozen or dried. Harvesting is best during temperatures of 22–25 °C.

3. Chemical composition of essential oils obtained from genus *Matricaria* plants

The essential oil is characteristic for some genera from the Asteraceae family, including the *Matricaria* genus, as commented before. Among species from this genus, the most popular and commercially important is *M. recutita* (Baser and Buchbauer, 2015). The essential oil is found in the whole plant (Das et al., 2002), but the flower head is mostly used for medicinal and aromatic purposes. Volatile compounds and sesquiterpene lactones are secreted to the multicellular biseriate glandular hairs and to the glandular ducts localized mostly on some parts of flowers—the former on the bract, corolla, ovary and the latter in the inflorescence peduncle, receptacle, bract, and stigma. Both secretory structures are present on stems and leaves but in considerably smaller amount (Andreucci et al., 2008). The monograph of *Matricariae flos* (*M. recutita* flower) is placed in many national pharmacopoeias and European Pharmacopoeia (EP) which recommend that chamomile contains no less than 4 mL/kg of blue essential oil (Schilcher, 2005). In addition, *Matricariae aetheroleum* (*M. recutita* oil) also has its monograph in EP, in which two types of oil are mentioned—rich in bisabolol oxides (29–81%) and rich in levomenol (10–65%) (European Directorate for the Quality of Medicines and Healthcare, 2004).

The essential oil is obtained from the fresh or dried inflorescences by steam distillation. Sometimes this process is long-drawn (even 7–13 h) and additionally cohobation of remaining water is being carried out. The yield of the process is around 0.3–1.5% and depends on origin and quality of the source. This is a deep blue, viscous liquid with an intense characteristic herbaceous odor (Schilcher, 1987; Sticher, 2010).

There is a big diversification in qualitative and quantitative composition of volatile fractions obtained from the plant materials from various countries and regions of origin. Nevertheless, the primary constituents are sesquiterpenes such as (-)-α-bisabolol (levomenol, 5–70%), bisabolol oxide A (5–60%), bisabolol oxide B (5–60%), bisabolone oxide (0–8%), (*E*)-β-farnesene (7–45%), chamazulene (1–35%), and polyacetylenic compounds named spiroethers, existing in two isomeric forms, *trans*-(*Z*)- and *cis*-(*E*)-en-yne-dicycloether (2–30%). Monoterpenes like limonene (0.1%), (*Z*)-β-ocimene (0.69%), γ-terpinene (0.17%) and artemisia ketone (0.32%) were also detected (Wichtl, 2004; Heuskin et al., 2009). Fig. 1 presents the most abundant compounds of chamomile essential oil.

Tirillini et al. (2006) have identified the largest number of components of *Matricaria* essential oil. They analyzed separate elements of flower heads—ligulate and tubular florets and receptacle from plants growing in Italy. In all cases, more than 70 compounds were identified representing about 99% of the components of the oils. The oxygenated sesquiterpenoids and sesquiterpene hydrocarbons were predominating in essential oil from tubular florets obtained with a yield of 0.95%, the