Hop and Medicinal Plants, Year XXVII, No. 1-2, 2019
ISSN 2360-0179 print, ISSN 2360-0187 electronic

A COMPREHENSIVE REVIEW REGARDING THE BOTANICAL ORIGIN, MEDICINAL USES AND CHEMICAL COMPOSITION OF ROMAN AND GERMAN CHAMOMILE

CHIȘ Maria-Simona, Adriana PĂUCEAN, Simona MAN, Anamaria POP, Andruța Elena MUREȘAN, Georgiana FOSTOC, Sevastița MUSTE*
University of Agricultural Sciences and Veterinary Medicine, Faculty of Food Science and Technology, Food Engineering Department, 3-5 Mănăstur Street, 400372, Cluj-Napoca, Romania;
*Corresponding author e-mail: sevastita.muste@usamvcluj.ro

Abstract: Chamomile plant it is considered an amazing medicinal one, being the most widely used in all over the world. Due to its pleasant taste and its calming, sedative, therapeutically and medicinal effects, this plant is used in different industries. The chemical composition of chamomile is rich in total phenols, organic acids, terpenes, flavonoids, fatty acids, tocopherols, carotenoids and volatile compounds. The main product manufactured from chamomile is essential oil, recognized thanks to its antibacterial, anti-inflammatory, fungicidal, vermifuge, aromatherapy and antioxidant properties. Roman and German chamomile are the most common species from *Asteraceae* family being used in the production of tea, essential oils, products with medicinal and pharmaceutical uses and food industry.
***Keywords*:** chamomile, *Matricaria chamomilla* L., *Anthemis nobilis* L., bioactive compounds, medicinal.

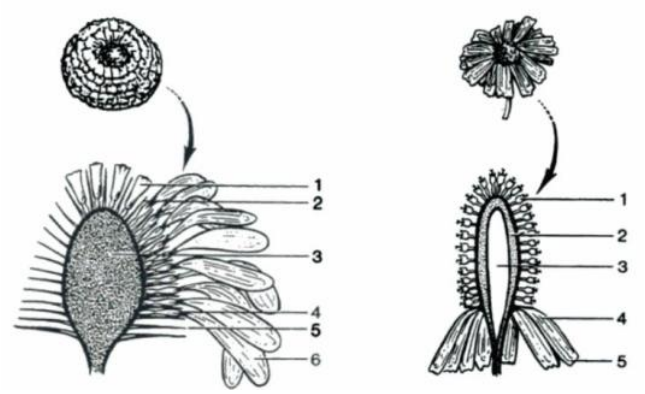
Introduction and botanical origins

Chamomile is an annual plant from the *Asteraceae* family, one of the most popular medicinal plant with different uses such as food industry (beverages, ice-cream, bakery products), tobacco, cosmetics, perfumery, aromatherapy, pharmacology and medicine (Iuliana & Tab, 2008; Formisano *et al.*, 2014; Moumita, 2014). The name Chamomile had its origins in two Greek words: *Khamai* which means on the ground and melon, which means apple. The chamomile was used in ancient times as a medicinal plant and Egyptians considered the plant as a gift from the God of the Sun, being a sacred plant, according to Moumita (2014).

Chamomile is a very important medicinal plant species, native from south and east Europe but widespread in all Europe, north Africa, Asia, America, Australia and New Zealand (Alyari *et al*., 2006).

The chamomile name is used for three species such as German or Hungarian chamomile *Matricaria chamomilla* L. (synonyms *Chamomilla recutita* (L.), Rauschertand *Matricaria recutita* L.) Roman chamomile, known as *Anthemis nobilis* L. (synonyms *Chamaemelum nobile* L. All.) and Juhua (*Chrysanthemum morifolium* Ramat.) according to Formisano *et al.* (2014) and Wang *et al.* (2014).

German or Hungarian chamomile (*Matricaria chamomilla* L.) is characterized as a plant with a height of approximately 50 cm, with an erect branched stem which grows to a height of 15-15 cm. The leaves are bipinnate or tripinnate with flowers carried in paniculate capitula. The receptacle is between 6-8 mm wide, with different forms: flat at the beginning ending with a cone-shaped form later. The receptacle form is a very important distinctive characteristic of *Matricaria chamomilla* L. (Singh, Khanam, Misra & Srivastava, 2011). The differences in flower morphology between Roman and German chamomile are illustrated in Figure 1.



A. Roman Chamomile
1. Tubular disc floret
2. Paleae
3. Receptacle
4. Stigma
5. Involveral bracts
6. Ligulate ray floret

B. German Chamomile
1. Tubular disc floret
2. Receptacle
3. Air space
4. Ligulate ray floret
5. Floret ribs

Fig. 1. The flowers of Roman and german Chamomile
(Source: Mann & Staba, 2004)

Roman chamomile (*Chamaemelum nobile* L. All), a Mediterranean perennial plant, has a weight of 16-32 cm and the stems are trailing divided. The flowers are big, with a white colour and a strong an enjoyable odour (Omidbaigi, Sefidkon, & Kazemi, 2004). It has in middle part of the capitulum small setiform paleae (Sharafzadeh & Alizadeh, 2011). According to Sharafzadeh & Alizadeh (2011), German chamomile is more cultivated than the Roman one.

Medicinal uses of Roman and German chamomile

Chamomile flowers should contain a minimum of 0.4% essential oil and 0.25% of apigenin 7-glucoside, according to European Pharmacopoeia (EP), as reported by Formisano *et al.* (2014). The amount of essential oil from the chamomile flowers is usually between 0.4 - 2%, and contains more than 120 components such as terpenoids, farnesene, spathulenol, spiroethers and azulenes.

This is in line with other finding such as Singh *et al.* (2011), who reported that the chamomile flower contain more than 120 constituents such as 28 terpenoids, 36 flavonoids and 52 compounds that could be involved in pharmacological activity.

Chamomile, Roman or German varieties, are widely used in a numerous number of commercial products with medicinal purposes, but the most common one is the German chamomile (*Matricaria chamomilla L.)*, known due to its chemical composition rich in bioactive compounds such as essential oils, polyphenols, flavonoids, coumarins (Formisano *et al.*, 2014). The essential oil from German chamomile is used in food and beverages industries in order to improve their organoleptic characteristics such as flavour, taste and colour. It is also used in aromatherapy, massage and bath or as a compress (Moumita, 2014).

Chamomile is a plant widely used all over the world and could be used as a sedative, antispasmodic, anxiolytic, with positive effects on skin irritation and inflammation. It is also used as a home remedy (Sharafzadeh & Alizadeh, 2011) and it is recognised by FDA (Food and Drug Administration) as being GRAS (generally recognized as safe) (Srivastava, Shankar, & Gupta, 2010).

German chamomile tea is one of the most consumed teas all over the world, almost a million cups being consumed every day (Moumita, 2014). Also, German chamomile fresh flowers could be also used in the manufacture of salads and drinks. The dried flowers could be used as a raw material in soups, salads, non-alcoholic beverages such as lemonade.

On the other side, also Roman chamomile flowers tea is recognized in the folk medicine as being used thanks to its improving effects on stomach diseases and nausea (Gilligan, 2005).

German chamomile is also used in the treatment of sore stomach, of irritable bowel syndrome, as a laxative, having also anti-inflammatory and bactericidal effects (Alireza, 2012), being a raw material for drug elaboration. As having antiseptic, carminative, sedative, spasmolytic and anti-inflammatory effects, the chamomile drug is included in the pharmacopoeia of 26 countries (Alyari *et al.*, 2006).

On the other side, the Roman chamomile it is recognized to have sedative, carminative, antispasmodic, antiemetic properties and could have antibacterial affects against *Porphyromonas gingivalis*, an endogenous bacteria responsible for periodontitis (Sharafzadeh & Alizadeh, 2011).

Also, Roman chamomile has been used for centuries for medicinal purposes through oral dosage such as decoctions and infusions, being a rich source in 5-O-caffeoylquinic acid and an apigenin derivative (Guimarães *et al.*, 2013).

The antifungal activity of German chamomile (*Matricaria chamomilla L.)* against *Bacillus cereus, Bacillus subtilis, Staphylococcus aureus* was proved by Alireza (2012), as showed in Figure 2.

Tested bacteria	MTCC No.	Zone of inhibition (mm)	
		Oil in DMSO (1:2)	Streptomycin 1 mg/ml
Gram-positive bacteria			
Bacillus cereus	430	11.5	7.5
Bacillus subtillis	441	8	11
Staphylococcus aureus subsp. Aureus	2940	13.5	12.5
Gram-negative bacteria			
Escherichia coli	443	8	13
Klebsiella pneumoniae	109	9	9.5
Proteus vulgaris	426	11.5	10
Salmunella typhi	733	8.5	9

Fig. 2. Antibacterial activity of the aerial parts oil of *Matricaria chamomilla* L. (Source: Alireza, 2012)

The German chamomile essential oil, due to its chemical composition was reported by Sebai, Jabri, Souli, Hosni & Rtibi (2017), as having neuro-protective, anti-allergic, anti-microbial and anticancer effects. The biological activity of *Matricaria chamomilla* L. is showed in Figure 3. This study also showed that German chamomile decoction extract could have protective activity on the rat liver, due to its antioxidant effects. The German variety it is involved also in the inhibition of generalized anxiety disorder, according to Srivastava *et al.* (2010).

Activity	References
Analgesic	[98]
Antiallergic	[99]
Anticancer	[100]
Antihyperglycemic	[101]
Antiinflammatory	[102]
Antimicrobial	[103]
Antipruritic	[104]
Antisolar	[105]
Antispasmodic	[89,106]
Antistress	[107
Antiulcer	[108]
Anxiolytic	[109]
Arcaricadal property	[110]
Gastrointestinal disorders	[111]
Hepatoprotective	[112]
Immunomodulatory	[113]
Inhibition of poliovirus replication	[114]
Intracanal irrigant	[115]
Lousicidal, ovicidal, repellent	[116]
Prevent osteoporosis	[117]
Sedative	[118]
Treatment of infant botulism	[119]
Treatment of oral mucositis	[120]
Uterotonic	[121]
Virucidal agent	[122]
Wound healing property	[123]

Fig.3. Biological activity attributed to *Matricaria chamomilla* L.
(Source: Singh *et al*., 2011)

Chemical composition

The German chamomile and the Roman one are quite different regarding their essential oil and chemical composition. More than the genetic influence, also the environmental conditions, soil composition, postharvest handling could influence the chemical composition of the plant and hence, the chemical composition of the volatile oils. The colour of the chamomile oil is blue, due to the presence of the terpenoid chamazulene, which represent approximately 5% of the essential oil (Sharafzadeh & Alizadeh, 2011).

The main component of the German chamomile *(Matricaria chamomilla* L.) is terpene bisabolol. Also, according to Alireza (2012), farnesene, chamazulene, flavonoids such as quercetin, luteolin and patuletin, and coumarin are between the bioactive components of German chamomile. In the German chamomile extract, as reported by Singh *et al.* (2011), it was found a total amount of 11 phenolic compounds such as chlorogenic acid, caffeic acid (phenylpropanoids), apigenin, apigenin- 7-O-glucoside, luteolin and luteolin-7-O-glucoside (flavones), quercetin and rutin (flavonols) and naringenin (flavanone) and herniarin and umbelliferone (coumarin).

The German chamomile essential oil extracted from the flowers has as a principal component (E)-β-farnesene (4.9–8.1%), followed by terpene alcohol (farnesol), chamazulene (2.3–10.9%), α-bisabolol (4.8–11.3%), and α-bisabolol oxides A (25.5–28.7%) and α-bisabolol oxides B (12.2–30.9%), according to Singh *et al.* (2011).

The active substances from Roman chamomile (*Chamaemelum nobile* L. All) are classified in terpenoids such as bisabolol and chamazulene, flavonoids such as luteolin, apigenin, quercetin, coumarins such us scopoletin-7-glucoside and more components such as fatty acids, choline (Sharafzadeh & Alizadeh, 2011). Compared with the German chamomile, the Roman one contains a smaller amount of chamazulene and it has as a principal component esters of angelic and tiglic acid together with compounds such as pinene and farnesene (Srivastava *et al.*, 2010). Due to the pinene components, Roman essential oil could attenuate the depressive-like behaviours in Wistar-Kyoto (WKY) rats through oil inhalation (Kong *et al.*, 2017).

In other study, Roman chamomile oil extracted by hydrodistillation proved to be rich in angelic acid, angelic acid butyl ester, isobutyric acid ester, 3-phenyl propyl isobutyrate, 2-phenylethyl isobutyrate, phenylethyl propionate and chamazulene (Omidbaigi *et al.*, 2004).

Roman chamomile oil from France has a rich chemical composition in volatiles compounds such as isobutyl angelate, isobutyl isobutyrate, 2-methylbutyl 2-methylbutyrate, as showed in Figure 4, (Taylor *et al.*, 2011).

Compound	Concentration[a]
isobutyl angelate	32.1%
2-methylbutyl angelate	16.2%
isobutyl isobutyrate	5.3%
methyl 2-methylbutyrate	1.9%
prenyl acetate	1.4%
2-methylbutyl 2-methylbutyrate	1.2%
2-methylbutyl acetate	1.2%

Fig. 4. Composition of main target-compounds of Roman chamomile oil from France (Source: Taylor *et al.*, 2011)

Due to the rich chemical composition, chamomile oil had antimicrobial activity against gram negative bacteria such as *Escherichia Coli, Pseudomonas aeruginosa, Klebsilla pneumoniae* and *Salmonella sp.* and yeasts such as *Candida albicans* (Taylor *et al.*, 2011).

This is in line with other study reported by Chao *et al.* (2011), who examined the inhibitory effect of 45 essential oils on microorganisms such as bacteria, yeast, moulds and bacteriophage. Between all the oils, Roman chamomile and lemongrass oils proved the highest antimicrobial properties on phage (Chao *et al.*, 2011).

Also, Chao *et al.*, 2008, reported in another study that Roman chamomile could have inhibition activity against methicillin-resistant *Staphylococcus aureus*, showing an inhibition zone of 19 mm, while German

chamomile could not show exhibition zones against *Staphylococcus aureus (0 mm)*, as showed in Figure 5.

Oils	Botanical name	Diameter (mm)
Angelica	*Angelica archangelica*	14
Anise	*Pimpinella anisum*	15
Basil	*Ocimum basilicum*	18
Bay laurel	*Laurus nobilis*	17
Bergamot	*Citrus bergamia*	0
Blue cypress	*Callitris intratropica*	17
Cajuput	*Melaleuca leucadendra*	19
Cardamom	*Elettaria cardamomum*	17
Carrot seed	*Daucus carota*	17
Cedarwood	*Cedrus atlantica*	15
Celery seed	*Apium graveolens*	15
Chamomile, German	*Matricaria recutita*	0
Chamomile, Roman	*Chamaemelum nobile*	19

Fig.5. Zones of inhibition of methicillin-resistant *Staphylococcus aureus* by essential oils (Source: Wiley, Chao, Young, Oberg & Nakaoka, 2008)

In a study reported by Zhao *et al.* (2014), the octulosonic acid separated through modern chemical analysis from Roman chamomile, proved to have positive influences against inflammation and metabolic disorder.

Due to the bioactive components such as flavonoids (apigenin and luteolin) which are present in *Matricaria chamomilla* L. and *Chamaemelum nobile* L. *All*, chamomile possess antispasmodic, carminative and anti-inflammatory effects. Compared to the Roman chamomile, the German one has in the composition spiroethers cis- and trans-en-yn-dicycloether, which are considered to have antifungal, anti-inflammatory and spasmolytic properties (Sharafzadeh & Alizadeh, 2011).

The phenolic compounds such as flavonols, flavones, phenolic acids and organic acids are correlated with antioxidant and antitumor effects without having second negative properties (Guimarães *et al.*, 2013). The organic acids of Roman chamomile are listed in Figure 6.

On the other side, Roman chamomile represent an important species with a high content of proteins, carbohydrates, tocopherols, carotenoids, phenolic compounds and fatty acids (Guimarães *et al.*, 2013).

Organic acid	Herb	Decoction	Infusion
Oxalic acid	2.02 ± 0.06^{a}	1.74 ± 0.21^{b}	1.99 ± 0.13^{ba}
Quinic acid	1.74 ± 0.13^{b}	1.40 ± 0.04^{b}	2.56 ± 0.17^{a}
Malic acid	3.02 ± 0.07^{a}	2.21 ± 0.19^{b}	3.06 ± 0.05^{a}
Citric acid	1.33 ± 0.01^{a}	1.23 ± 0.16^{a}	1.46 ± 0.24^{a}
Fumaric acid	0.02 ± 0.00^{a}	0.01 ± 0.00^{b}	0.01 ± 0.00^{b}
Total (g/100 g)	8.14 ± 0.28^{b}	6.58 ± 0.28^{c}	9.07 ± 0.01^{a}

In each row different letters mean significant differences ($p < 0.05$).

Fig. 6. Organic acids composition of Roman chamomile (mean ± SD) (Source: Guimarães *et al.*, 2013)

The anticancer activity of chamomile is considered to be due to the presence of apigenin, a bioactive compound present in both chamomile varieties. Studies made on preclinical models of different types of cancer (skin, ovarian, prostate, breast) showed that chamomile extract could significantly reduce the cell viability in this human cancer cell lines (Srivastava *et al*., 2010).

Due to its high antioxidant activity expressed in radical scavenging activity (94.8% RSA), to its high amount of polyphenols (21.4 ± 0.327 mg GAE/g) and high flavonoids content (157.9 ± 2.22 mg QE/g), German chamomile could be a potential in anti-cancer treatments (Dabbagh *et al.*, 2019).

In a recent study, Kreuter, Naby, Kemmler, & Ghazaly (2019) showed that chamomile extract administrated orally before irradiation could be a novel therapeutic strategy for the protection against intestinal mucositis.

Moreover, apart from the antioxidant, anti-inflammatory, anti-cancer, antimicrobial activities, chamomile extract could have an important antidiabetic effect, as showed in a rats study realized by El Safer *et al.* (2019).

Conclusions

Chamomile represents a promising medicinal plant for the future having multiple uses such as medicines, pharmacology, food industry, and aromatherapy. It is also used as a protective agent against microorganisms' development due to its chemical composition.

Nowadays, the recent studies reported that this plant could be involved in the treatment of different diseases such as cancer and diabetes. To support this idea much more clinical trials need to be done, representing a new research area with a big potential.

References

1. Alireza, M. (2012). Antimicrobial activity and chemical composition

of essential oils of chamomile from Neyshabur, Iran, Journal of Medicinal Plants Research, 6(5):820–824.
2. Chao, S.C., Young D.G., Oberg C.J., Chao S.C., Young D.G., Oberg C.J. & Oberg C.J. (2011). Screening for inhibitory activity of essential oils on selected bacteria, fungi and viruses screening for inhibitory activity of essential oils on selected bacteria, fungi and viruses, Journal of Essential Oil Research, 12:639-649.
3. Dabbagh, A., Res B.M.C., Dabbagh B., Al Elhaty I.A., Elhaw M., Murali C. & Mansoori A.Al. (2019). Antioxidant and anticancer activities of chamomile (*Matricaria recutita* L.), BMC Research Notes, 1–8.
4. Pirzad, A., Alyari H., Shakiba M.R., Zehtab-Salmasi S. & Mohammadi A. (2006). Essential oil content and composition of German chamomile (*Matricari chamomilla* L.) at different irrigation regimes. Journal of Agronomy 5(3):451-244.
5. Formisano, C., Delfine S., Oliviero F., Carlo G., Rigano D. & Senatore F. (2014). Correlation among environmental factors, chemical composition and antioxidative properties of essential oil and extracts of chamomile (*Matricaria chamomilla* L.) collected in Molise (South-central Italy), Industrial Crops & Products, 1-8.
6. Gilligan, N.P. (2005). The palliation of nausea in hospice and palliative care patients with essential oils of *Pimpinella anisum* (aniseed), *Foeniculum vulgare* var. *dulce* (sweet fennel), *Anthemis nobilis* (Roman chamomile) and *Mentha x piperita* (peppermint), 163–167.
7. Guimarães, R., Barros L., Calhelha R. C., Maria A., Santos-Buelga C., João M., Ferreira I.C.F.R. (2013). Nutrients, phytochemicals and bioactivity of wild Roman chamomile: A comparison between the herb and its preparations, 136:718–725.
8. Iuliana, M. & Tab V. (2008.). Exploitation possibilities of chamomile in the conditions of west romanian plain, Hop and Medicinal Plants, 16:1-2.
9. Kong, Y., Wang T., Wang R., Ma Y., Song S., Liu J., Li S. (2017). Inhalation of Roman chamomile essential oil attenuates depressive-like behaviours in Wistar Kyoto rats, Sci China Life Sci, 60(6):647–655.
10. Kreuter, M. H., Naby A., Kemmler M. & Ghazaly M.A.El. (2019). Effect of a chamomile extract in protecting against radiation - induced intestinal mucositis, Phytotherapy Research., 1–9.
11. Mann, C., Staba E.J. (2004). The chemestry, pharmacology and comercial formulation of chamomile, Herbs, Spices, and Medicinal

Plants: Recent Advances in Botany, 1:235-242.
12. Omidbaigi, R., Sefidkon F. & Kazemi F. (2004). Influence of drying methods on the essential oil content and composition of Roman chamomile, Flavour and Fragrance Journal, 196–198.
13. Sebai, H., Jabri M., Souli A., Hosni K. & Rtibi K. (2017). Chemical composition, antioxidant properties and hepatoprotective effects of chamomile (*Matricaria recutita* L.*)* decoction extract against alcohol-induced oxidative stress in rats, Gen. Physiol. Biophys. 34:263-275.
14. Sharafzadeh, S. & Alizadeh O. (2011). German and Roman Chamomile, Journal of Applied Pharmaceutical Science 1(10):1–5.
15. Singh, O., Khanam Z., Misra N. & Srivastava M.K. (2011). Chamomile (*Matricaria chamomilla* L.): An overview. Pharmacognosy Reviews 5(9):82-95.
16. Soden, K., Vincent K., Craske S., Alice P., Lucas C., Medical D. & Hospice, P.A. (2004). A randomized controlled trial of aromatherapy massage in a hospice setting, Palliative Medicine, 18:87-92.
17. Srivastava, J. K., Shankar E. & Gupta S. (2010). Chamomile: A herbal medicine of the past with a bright future (Review), Molecular Medicine reports 3:895–901.
18. Taylor, P., Bail S., Buchbauer G., Jirovetz L., Denkova Z., Slavchev A., Schmidt E. (2011). Antimicrobial activities of roman chamomile oil from France and its main compounds antimicrobial activities of roman chamomile oil from France and its main compounds, Journal of Essential Oil Research, 37–41.
19. Wang, M., Avula B., Wang Y., Zhao J., Avonto C., Parcher J.F., Khan I.A. (2014). An integrated approach utilising chemometrics and GC/MS for classification of chamomile flowers, essential oils and commercial products, Food Chemistry, 152:391–398.
20. Wiley, J., Chao S., Young G., Oberg C. & Nakaoka K. (2008). Inhibition of methicillin-resistant *Staphylococcus aureus* (MRSA) by essential oils, Flavour Frag. J., 444–449.
21. Zhao, J., Khan S.I., Wang M., Vasquez Y., Yang M.H., Avula B., Khan I.A. (2014). Octulosonic acid derivatives from roman chamomile (*Chamaemelum nobile*) with activities against in fl ammation and metabolic disorder, Journal of Natural Products, 509-515.