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Chemical Composition and Biological Activities of Essential Oils of Genus *Tanacetum* - a review

Vinesh Kumar, Devendra Tyagi

ABSTRACT

The genus *Tanacetum* belongs to family Asteraceae or Compositae. Literature review revealed that *Tanacetum* species have been used as remedies in traditional medicine since ancient times throughout the world. The literature review of photochemical studies on different *Tanacetum* species had revealed the presence of large number of chemical constituents. The essential oil from *Tanacetum species* constitutes more than 200 compounds. *Tanacetum* species have traditionally been used in the manufacturing of cosmetics, insecticides, balsams, medicines, dyes, preservatives and in herbal remedies. Interest is increasing in species of *Tanacetum* due to its essential oils, the presence of sesquiterpene lactones and bitter substances, which has been exhibited biological activities like growth regulating, cytotoxicity, antimicrobial activity etc. This review study is an effort to collect all information regarding chemical composition and biological activities of genus *Tanacetum.*

Keywords: Asteraceae, Tanacetum, Photochemical, Cytotoxicity, and Essential Oil.

1. Introduction

The genus *Tanacetum* is a group medicinal herbs belonging to the family Asteraceae (Compositae). The Asteraceae or Compositae (commonly referred to as the aster, daisy, or sunflower family), is an exceedingly large and widespread family of vascular plants [1]. The group has more than 22,750 currently accepted species, spread across 1620 genera and 12 subfamilies. Along with the most members of Asteraceae are herbaceous, but a significant number are also shrubs, vines and trees. The family is distributed throughout the world and most common in the arid and semi-arid regions of subtropical and lower temperate latitudes [2]. The genus *Tanacetum* contains, totaling over 200 species and distributed over West Asia and Europe. The genus includes several strongly scented annual and perennial species. *Tanacetum* species are widespread in many countries of North America, Asia, and Europe [4-12]. The species are growing up to altitude of 200 meters, contains several strongly scented annual and perennial species.

Interest is increasing in species of *Tanacetum* due to its essential oils (cordial, stomachic and used as a food preservative), bitter substances and the presence of sesquiterpene lactones, which exhibited biological activities like cytotoxicity, antimicrobial activity, and growth regulating [3].

The species of genus *Tanacetum* have been used in popular medicine as expectorants, antiseptic vermifuges, and spasmolytics [4]. In Bulgaria, the dry leaves and flowers of *T. vulgare* are used as spasmodic, antiseptic and for protecting against dandruff [5]. The leaves of *T. parthenium* are used as a popular British traditional herbal remedy for the prophylaxis of migraine [6]. This review was aimed to collect and summarized all information on Chemical composition and biological activities of essential oils of genus *Tanacetum.*

2. Chemical Composition

The essential oils isolated from *Tanacetum* species have variable chemical constituents. Chemo-variation is a well-known fact in *Tanacetum* species which is encountered on species level [10-11], and on subspecies level [11-12].

The main chemical constituents reported in the essential oils of *Tanacetum* were camphor, bornyl acetate, α–phellandrene, chrysanthenyl acetate, α –terpinene, p-cymene, terpinene-4-ol, α–terpineol, verbenone, *α*-phellandrene, *α*-terpinene, tetradecane, caryophyllene oxide. *α-thujene*, *α*-pinene, camphene, *β*-pinene, *p*-cymene, limonene, *γ*-terpinene, benzaldehyde, sabinene, pinocarvone, borneol myrtenal, β-caryophyllene, (e)-*β*-farnesene, valencene,

β-bisabolene thymol, and carvacrol [28-29].

Tabanca *et al*, reported *cis*-verbenol, *trans*-pinocarveol, α-pinene, camphene, β-pinene, sabinene, α-6terpinene, limonene, isoamyl alcohol, γ-terpinene, 2-methyl butyrate, *p*-cymene, isoamylisovalerate, octanal, 6-methyl-5-hepten-2-one, benzaldehyde, *cis*-sabinenehydrate, 1-methyl-4-acetylcyclohex-1-ene, *trans*-*p*-menth-2-en-1-ol, pinocarvone, *trans*-sabinenehydrate, α-campholene aldehyde, camphor, bornylacetate, terpinen-4-ol, β-caryophyllene, *p*-mentha-1,5-dien-8-ol, *trans*-verbenol, δ-cadinene, γ-cadinene, *ar*-curcumene, *cis*-sabinol, myrtenol, *cis*-jasmone, isocaryophyllene oxide, α-humulene, α-terpineol, borneol, germacrene-d, caryophyllene oxide, humulene epoxide-i, (*e*)-lavandulyl acetate, spathulenol, (*e*) sesquilavandulol, thymol, carvacrol, α-cadinol, *cis*- α-*trans*-bergamotene acetate, decanoic acid, caryophylla-2(12),6(13)-dien-5-ol (caryophylladienol-ii), pentacosane heptacosane, hexadecanoic acid, monoterpene hydrocarbons, sesquiterpene hydrocarbons, oxygenated monoterpenes, and oxygenated sesquiterpenes in the essential oil of *T. argentums* [30]. Germacrene, sesquiterpenes and spathulenol were reported as major components in the oil of *T. zahlbruckneri* [31]. The main chemical constituents reported in the essential oil of *T. tabrisianum* were 1, 8-cineole, caryophyllene oxide, hexadecanoic acid, decanoic acid, spathulenol and *trans*-l linalool oxide. acetate [31].

Chrysanthenone, α-thujene, linalool, camphor, pinocarvone, α-pinene, β- pinene, β-myrcene, camphene, 1,8-cineole, γ-terpinene, *trans*-linalool oxide, thuj-3-en-10-al, myrtenal, α-terpineol, *cis*-chrysanthenyl acetate, , *z*-jasmone, linalool butyrate, menthyl isovalerate, bornyl acetate, carvacrol, geranyl acetate *cis*- sabinene hydrate, *trans* sabinene hydrate, borneol, lavandulyl acetate, *cis*-jasmine, neryl acetone, bornyl isovalerate, spathuleol, β-selinene, δ-cadinene, nerolidol, caryophyllene oxide, carvone, geraniol, *cis*-chrysanth, hexadecanoic acid, octadeca-1-ol, phytol tricyclene, e-sesqui-lavandulol, octadecane, benzyl benzoate, *trans* sabinene, tricosane and n-docosane were identified in the oil of *T. polycephalum* [32].

Santolina triene, α-thujene, α-pinene, yomogi alcohol, α-terpinene, *p*-cymene, camphene, β-pinene, 1,8-cineole, artemisia ketone, *cis*-sabinene hydrate, *trans*-thujone, chrysanthenone, *trans*-limonene oxide, *trans*-pinocarveol, umbellulone, terpin-4-ol, *cis*-linalool oxide, *cis*-thujone, α-terpineol, β-eudesmol, *cis*-pinocamphone, *cis*-chrysanthenyl acetate, thymol, *cis*-carvyl acetate, isopinocampheol, *trans*-chrysanthenyl acetate, γ-muurolene, davanone, monoterpene hydrocarbons, oxygenated monoterpenes, sesquiterpene hydrocarbons, and oxygenated sesquiterpenes were reported in the essential oil of *T. santolinoides* [33].

Previous investigations reported that essential oil compositions of *T. chiliophyllum* collected from different locations had different chemical constituents. According to these reports it was observed that there were three different chemotypes of this plant with camphor (28.5%), 1, 8-cineole (17.1%), camphene (7.1%), isobornyl propionate (5.4%) [6]; camphor (17.9%), 1, 8-cineole (16.6%), borneol (15.4%), dihydro-α-cyclogeranyl hexanoate (10.1%) [8] and camphor (16.8%), *cis*-chrysanthenyl acetate (16.3%), α-thujone (12.5%) as main constituents [5].

Forty five components were reported in the essential oils of dried aerial parts of *Tanacetum balsamita,* representing 81.0% of the oils, respectively. *Trans*-chrysanthenol (22.3%), chrysanthenyl acetate (19.7 %), linalool oxide (11.5 %), camphor (7.5 %), 1, 8-cineole (2.7 %) were found as major components in *T. balsamita* subsp. *Balsamita.* Ateya reported twelve compounds in the essential oil of the flower heads, such as β-eudesmol (15.4%), fenchone (10.8%), thymol (6.9%) and benzyl acetate (6.2%) possibly *cis*-chrysanthenol (27.5%) and *trans*-chrysanthenol (8.9%) as major constituents [14].

Camphor, 1, 8-cineole α-thujone, β-thujone, borneol, chrysanthenone, α-chrysanthenone sabinene, and camphene, p-cymene, isothujone, and bornyl acetate have been reported in *T. vulgare* [35-38]. α–thujone (51%), and β-thujone (10%) were the major constituents of *Tanacetum messicyticu* [39].

Borneol (28.0%), and 1, 8 cineole (12%) were reported as the major constituents of essential oil of *Tanacetum praeteritum* [39]. **α**-cadenine (50.9 %) and β-cadinene (15.1%) were reported as the major constituent of essential oil of *Tanacetum corymbosum* [40]. The leaf and flower oils of *T. argyrophyllum* were dominated by caryophyllene oxide and α–thujone. Sesquiterpene lactones and coumarins have also been reported from various *Tanacetum species* [41-42, 45].

3. Biological Studies

Tanacetum species have been used for centuries as folk remedy because of their diverse biological activities. The genus is rich source of bioactive compounds such as sesquiterpenoids, flavonoids and essential oils [52-55], which are implicated in most of biological activities of the genus *Tanacetum*. Some biological activities of *Tanacetum* genus are briefly described here.

3.1 Antimicrobial Activity

The results exhibited that the total oils of *Tanacetum balsamita* possess moderate antimicrobial activities against all the tested microorganisms [56]. *T. parthenium* has been reported for anti-bacterial and anti-fungal activities [57]. Antimicrobial activity have been reported of the essential oils isolated from *T. parthenium* [58], *T. vulgare* [59], *T. corymbosum* [60], *T. macrophyllum* [61], and *T. cilicium* [62].

3.2 Antibacterial Activity

The parthenolide present in the *T. parthenium* plant leaves and seeds has been found active against gram positive bacteria, yeast and filamentous fungi [63-65]. The sesquiterpene lactones, tanargyrolide, tabulin, iso special form, 8-α-hydroxy anhydroverlotorin, tanacchin, a germacranolide with 1,5- ether linkage and dentatin A, isolated from *T. var. argyrophyllum* exhibited bactericidal effects against *Staphylococcus aureus,* and *Escherichia coli* [66].

3.4 Antifungal Activity

The plant extracts of *T. parthenium* were exhibited antifungal activity against *Candida albicans, Candida tropicalis.*

3.5 Antioxidant Activity

Tanacetum products are widely used in health food as food preservatives, while tansy extracts can be effectively used as antioxidant in rapeseed oil [67].

3.6 Epileptogenic activity

Epileptogenic property (i.e. powerful convulsants) of tansy have been known for long time since it has highly reactive monoterpenes such as pinocamphone, thujone, camphor, 1,8 cineole, pilgene, and sabinylacetate [68].

3.7 Anti-inflammatory Activity
Anti-inflammatory activity has also been reported in some species of *Tanacetum*. *T. microphyllum* was useful in treating various inflammatory disorders [69]. *T. vulgare* extracts have been shown to inhibit carrageenan -induced rat paw edema [70]. The inflammatory activity has also been reported for *T. vulgare* and *T. larvatum* [71-72]. In a human polymorphonuclear leukocyte based bioassay, it was observed that some species of *Tanacetum* such as *T. vulgare, T. ptarmiciflorum, T. parthenium,* and *T. niveum,* inhibited phorbol myristate induced chemiluminescence of human polymorphonuclear leukocyte [73-74]. Anti-inflammatory activity of *Tanacetum* is attributed to its parthenolide contents that impair platelet activation in human blood [75]. However, some other compounds such as flavonoids present in the plant may cause anti-inflammatory effect [76-77].

3.8 Anthelmintic Activity
The ether extracts, essential oils and β-thujone isolated from *T. vulgare* has been exhibited anti- anthelmintic activity [78].

3.9 Allergen Activity (Contact dermatitis)
Contact dermatitis also known as "chrysanthemum allergy" or "compositae dermatitis" has been reported in florists and gardeners affected by the parts of Compositae plants [79]. Sesquiterpene lactones are believed to be the major constituent of Compositae responsible for contact dermatitis [80]. Cross-sensitivities have also been reported with phytochemically identical plant species. There are several clinical studies concerning contact dermatitis caused by *T. parthenium* [70-81], *T. vulgare* [80-82] and *Chrysanthemum cinerariaefolium (T. cinerariaefolium*) [82].

3.10 Anticoagulant and Antifibrinolytic Activities
Chloroform extracts, aqueous extracts and essential oils of *T. cilicium* [62], *T. corymbosum* [83] and *T. macrophyllum* were studied for their anticoagulant and antifibrinolytic activities. All extracts were found to exhibit remarkable anticoagulant activity as well as antifibrinolytic activity [84]. This indicates the anticoagulant and antifibrinolytic potential of the *Tanacetum* extracts.

3.11 Antiulcer Activity
8-β-hydroxyahillin isolated from the aerial part of *T. microphyllum* has also been shown to have antiulcer activity [85]. The flowers of *T. ferulaceum* have been used as antiulcer therapy [86]. *T. vulgare* and its constituent, parthenolide has been found effective in gastric ulcer in rats [87].

3.12 Phytotoxic activity
All of the compound isolated from *T. cinerariaefolium* such as α-methylene-β- lactone, have inhibited root growth of Chinese cabbage seedlings [88].

3.15 Anticancer Activity
Tanacetum species such as feverfew (*T. parthenium*) and its major constituents, parthenolide, sesquiterpene lactones have exhibited anticancer activity against cells derived from human carcinoma of the nasopharynx (KB) [53, 89]. Furthermore, parthenolide was shown to inhibited DNA synthesis in HeLa cell lines and it was suggested that the anti-tumour activity occurs at the DNA replication level, probably by interfering with the DNA template [90]. The cytotoxic effect of parthenolide occurs due to its action, such as serotonin release inhibition [91], protein tyrosine kinase [92], and protein kinase C inhibition [93], these enzymes have very important role in various aspects of cell cycling [94]. Other species such as *T. densum* ssp. *Sivasicum* [65], *T. argentums* Sp. *Argenteum* [95], and *T. praeterium* Sp. *Praeterium* [96] also possess cytotoxic activity.
The cytotoxic effect of *Tanacetum* is believed to occur due to its sesquiterpene lactones contents that showed cytotoxic activity against human cell lung carcinoma and the human colorectal cell lines [66].

3.16 Insecticidal activity
Another insecticidal activity occurring *via* antifeedent effect has been reported for germacranolide isolated from *T. argentums* ssp. *Argenteum,* the compound exhibited antifeedant activity against neonate larvae *Spodoptera littoralis* [95]. The active constituents isolated from *T. cinerariaefolium,* have been studied for insecticidal activity [97-99].
T. vulgare possesses insect repellent activity. The steam distillate of fresh leaves and flowers of tansy were found to be strongly repellent to Colorado potato beetles, *Leptinotarsa decemlineata.* The activity is believed to occur due to essential oils content of the plant [100].

3.17 Prophylactic Activity against Migraine
Feverfew has been known as an antimigraine folk remedy since ancient times and also effective in migraine prophylaxis [88, 100-101]. The crude extracts of *T. parthenium* and parthenolide also inhibit [^{14}C] 5-HT secretion and platelet aggregation induced by a range of platelet stimulating agents. Inhibition of human blood platelet function and its possible relevance to migraine prophylaxis by feverfew has also been studied [92].
The compound which is responsible for this activity is a germacranolide type sesquiterpene lactone, parthenolide. Extracts of feverfew as well as parthenolide have antisecretory activity may be related to the clinical effect of the herb [102]. The aqueous extracts of *T. parthenium also inhibit prostaglandin* (PG) biogenesis independent of cyclooxygenase [103].
T. parthenium has also been evaluated clinically in migraine patients, it was found effective and without adverse effects even at chronic treatment [101]. While another study has revealed beneficial effect of *T. parthenium* in migraine prevention [104] however patients using other anti-migraine drugs do not respond to therapy with feverfew [105]. Chloroform extracts of dried *T. parthenium* leaves produced reversible contraction of vascular smooth muscle, while fresh leaves caused an irreversible, non-specific inhibition of contractility [92, 106].

4. Conclusion
The genus *Tanacetum* belongs to family Asteraceae or Compositae. The family is distributed throughout the world and most common in the arid and semi-arid regions of subtropical and lower temperate latitudes Interest is increasing in species of *Tanacetum* due to its essential oils (cordial, stomachic and used as a food preservative), bitter substances and the presence of sesquiterpene lactones, which exhibited biological activities like cytotoxicity, antimicrobial activity, and growth regulating. The essential oils isolated from *Tanacetum* species have variable chemical constituents. *Tanacetum* species have been used for centuries as folk remedy because of their diverse biological activities. Further study should be carried out to isolates the active compounds for pharmaceutical and industrial purposes

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