

Spanish chamomile (*Anacyclus pyrethrum*) and pyrethrum (*Tanacetum cineraiifolium*): organic and natural pesticides and treasure of medicinal herbs

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Abstract

Pyrethrum (*Tanacetum cineraiifolium*) which is a natural insecticide has many properties, but the most important are rapid action, very low toxicity for mammalian, lack of insect immunity, broad of activity, lack of persistence and degraded quickly by UV in sunlight and very effective insect repellent. Organic farmers can use pyrethrins as an insecticide for fruit and vegetable crops. Easily degraded by oxygen, light and temperature, pyrethrum compounds are environmentally friendly and compatible with organic farming. *A. pyrethrum* roots contain anacyclin, pellitorine, hydrocarolin, inulin, traces of volatile oil and sesamin. The roots of *A. pyrethrum* are used in traditional medicine of different countries to treat epilepsy, rheumatism, cephalalgia, paralysis and hemiplegia. *N-alkylamids* and ester pyrethrine are the main constituents of roots which have tremendous medicinal values. The plant is also a natural pesticide with considerable antimicrobial properties. It has also possessed antidepressant, anti-inflammatory, anticonvulsive, antimicrobial, local anaesthetic, oxidative DNA damage preventive, immunostimulatory, saliva-stimulating, male libido enhancing, anti-mutagenesis and insecticidal activities.

Keywords: *Anacyclus pyrethrum*; medical herb; natural pesticide; pyrethrum; *Tanacetum cineraiifolium*

Introduction

Herbal medicinal plants are commonly used for the cure and prevention of countless diseases because of low price and more effectiveness with low side effects (Sun *et al.*, 2019a, b; Sun *et al.*, 2021a, b, c). Medicinal plants play an important role in sustainable agriculture, food systems and it is also offering a holistic and meaningful approach to prevent diseases, and fight against insects and pests while making suitable usage of organic and herbal products (Shahrajabian *et al.*, 2020a, b, c). Medicinal plants contain phytochemical and bioactive compounds such as phenols, saponin, flavonoids, alkaloids and etc (Shahrajabian *et al.*, 2019a, b, c; Shahrajabian *et al.*, 2021).

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We gathered relevant and informative literature related to this research study from different sources. The goal of this review is survey on important traditional and modern pharmaceutical uses of *Tanacetum cineraiifolium* and *Anacyclus pyrethrum*.

***Tanacetum cineraiifolium* and *Anacyclus pyrethrum*, Occurrence and Cultivation**

Botanical insecticides keep attracting more attention from environmental and small farmers worldwide as they are considered as a suitable alternative to synthetic insecticides (Pavela, 2016). Pyrethrum (*Tanacetum cineraiifolium*) is a perennial in the Asteraceae that has been widely used for pyrethrin production (Wandahwa and Ranst, 1996; Hay *et al.*, 2008; Bhuiyan *et al.*, 2015; Bhuiyan *et al.*, 2018; Moslemi *et al.*, 2018). The interest in sustainable agriculture has increased in recent years, and the demand for plant-derived pesticides which can be less toxic both to mammals and to the environment (Keskitalo *et al.*, 1999; Kiriamiti *et al.*, 2003; Pethybridge *et al.*, 2004; Jansen *et al.*, 2010). Insecticidal pyrethrins are extracted from the achenes within the flower heads (Grdisa *et al.*, 2009), and represent the economically most important natural pesticide which are neurotoxins effective against a wide range of insect species, and broadly applied in private homes, gardens, stables and organic agriculture, because they have environmentally friendly properties. About 200 years ago, it was discovered in Central Asia. During the Napoleonic wars (1804-1815) this insect was used to control flea and body lice infestations by French soldiers. The white Chrysanthemum flower, pyrethrum, is mentioned in early Chinese history and it is believed to have passed into Europe along the silk routes. The first record of the pyrethrum was 2000 years ago at the time of China's Chou Dynasty, then the flowers have been traded along ancient Silk Road and was grown in the Dalmatian region. But, the species of plant was unknown, so, for convenience the history of pyrethrum usually starts with the mention in 1847 of the identified species *Chrysanthemum cinerariaefolium* found in Dalmatia which is part of Croatia. From 1885, bales of dried flowers were exported to the USA and during 1913, 500 tonnes were shipped. Although the earliest mention of the Chrysanthemum flowers from which it originates comes from early Chinese history, where it is believed that the flower passed into Europe along the silk roads. The term pyrethrum refers to the dried and powdered flower heads of a white-flowered, daisy-like plant belonging to the *Chrysanthemum* genus. Pyrethrum's insecticidal properties were recognized in the middle of the 19th century, when an American named Junticoff discovered that many Caucasus tribes used it for the control of the body lice. The earliest cultivation of pyrethrum, also called Persian pyrethrum or Persian powders, was in the region of the Caucasus extending into Northern Persia. The first Persian powders that were processed and commercialized in Europe in the 1820s were most likely prepared from a mixture of *C. roseum* and *C. corneum*. The first major commercial planting was done in Yugoslavia prior to 1914, thereafter Japan was the main producer until 1939 when Kenya and other East African countries took over after the second world war. Several attempts have been made to grow pyrethrum as a commercial crop in different parts of Australia between 1890 to 1964 (Bhat and Menary, 1984). Pyrethrum was first introduced into Tasmania and a crop improvement program begun in 1978. The commercial production of the crop started with selected clones from the program in 1984 (Bhat and Menary, 1984), and the crop is well established and commercially viable in Tasmania. Tasmania is one the largest pyrethrum producer. On a dry weight basis, a pyrethrum inflorescence contains the majority of the plants' active compounds, reported in the range 1-2% pyrethrins (Fulton, 1998; Sastry *et al.*, 2001). Pyrethrum is highly effective against many species of insects but its toxicity to people and warm-blooded animals is low because of its fast biotransformation (Duchon *et al.*, 2009; Sharafzadeh, 2011). Pyrethrum could be used by municipal utilities or in organic, integrated or conventional crop cultivation because of its natural origin and high biocide effect; pyrethrum has been used mainly for protection of cereal products, vegetables and animals, and it could also be used to protect human habitats and animals against insects. There are some possible uses: the first is spraying the fine dry pulp of flowers and the other spraying their extract. A third form is incense sticks to protect against mosquitoes causing malaria (Toth *et al.*, 2012). Pyrethrum is a white flower headed,

tufted perennial herbaceous plant possessing deeply lobed leaves, with numerous and fibrous shallow root system (30 cm). The plant has numerous fairly rigid stems that grow up to 50 to 80 cm in height with blue-green deeply divided leaves that are covered on both sides by a dense woolly material. Pyrethrum requires rich soils in phosphorous, calcium and magnesium with a minimum soil pH of 5.6. The appropriate situation is fertile and well drained soils with reasonably possess good texture and structure. This crop is spring sown, with its first harvest occurring approximately 15 months after establishment and up to three subsequent annual harvests thereafter (Vaghefi *et al.*, 2016). Ray blight is one of the most important disease of pyrethrum which produces typical necrotic symptoms on leaf margins, shoots and developing buds in spring (Pethybridge *et al.*, 2008; Vaghefi *et al.*, 2016). Pethybridge and Wilson (1998) reported that the most serious fungal foliar disease of pyrethrum in Tasmania is ray blight caused by *Phoma ligulicola*, the anamorph of *Didymella ligulicola*. The root of *Anacyclus pyrethrum* is used in traditional Iranian medicine (TIM), which has studied for anticonvulsant effects (Abdollahi and Shojaii, 2013). Ebn-e-Sina, prescribed it in erectile dysfunctions (ED) treatment (Khaleghi Ghadiri and Gorji, 2004). Ahmed and Venkataraman (1999) indicated that this crop constitutes a major part of poly-herbal ayurvedic medicine (PAM), which used for treating male sexual dysfunction in the Indian subcontinent. Boonen *et al.* (2011) reported that the roots of *Anacyclus pyrethrum* are frequently used in traditional medicine such as aphrodisiac. Hanane *et al.* (2014) confirmed that the phytochemical screening of *Anacyclus pyrethrum* has led to the identification of various secondary metabolites such as alkaloids, reducing compounds, tannins, flavonoids and coumarins. Scientific classification of *Anacyclus pyrethrum* is shown in Table 1.

Table 1. Scientific classification of *Anacyclus pyrethrum*

Kingdom	Plantae
Division	Spermatophyta
Sub-division	Angiosperms
Class	Dicotyledons
Sub-class	Metachlamydae
Order	Companulatae
Family	Compositaeor Asteraceae
Genus	<i>Anacyclus</i>
Species	<i>Pyrethrum</i>

Biochemical constituents of *A. pyrethrum* consist of chlorophyll a (0.240 mg/g), chlorophyll b (0.820 mg/g), total chlorophyll (1.060 mg/g), amino acid (160.0 mg/g), protein (3.140 mg/g), carbohydrate (1.726 mg/g), and phenol (0.788 mg/g) (Subrasi and Ahmed John, 2016). The root extracts contain steroids, triterpenes, reducing sugars, sugars, alkaloids, flavonoids, saponins, tannins, anthraquinones, and amino acids; and phytochemical compounds in their leaves are steroids, triterpenes, sugars, alkaloids, flavonoids, saponins, tannins, anthraquinones and amino acids (Subrashi and Ahmed John, 2016; Usmani *et al.*, 2016).

Treasure of medicinal herbs with tremendous benefits

Chesang *et al.* (2017) concluded that increased proportion of unstabilized pyrethrins in combination with diatomaceous earth offer grain protection comparable to the commercial chemical grain protectants. Pyrethrins can be separated into two groups of three ester compounds: pyrethrin I and II. The pyrethrin I fraction contains chrysanthemic acid products, including pyrethrin I, cinerin I, and jasmolin I. The pyrethrin II fraction is derived from pyrethric acid made up of pyrethrin II, cinerin II, and jasmolin II (Greening, 1983; Casida, 1990; Kimani and Sum, 1999; Elliott, 1995; Atkinson *et al.*, 2004). Pyrethrins also have the advantage over other synthetic insecticides of being rapidly broken down upon exposure to light and air, are metabolized quickly, and can be used in the production of organic farm products, and they generally considered to be non-polluting (Casida, 1990; Elliott, 1995). The plant *Anacyclus pyrethrum* consists of several *N*-alkylamides with

pellitorine as main constituents, and its extracts are already commercially available with functional cosmeceutical claims (Veryser *et al.*, 2014). Its root is widely used for treating various diseases in traditional Uygur medicine, particularly in the treatment of vitiligo (Ji *et al.*, 2019). Rachida *et al.* (2014) reported that *A. pyrethrum* roots widely used in Moroccan traditional medicine in treatment of teeth disease and in treatment of memory disorders, besides, a mixture of roots and milk added by honey is proposed as aphrodisiac, against the feminine infertility. The most important active constituents of pyrethrins are pyrethrin I (C₂₁H₂₈O₃), cinerin I (C₂₀H₂₈O₃), jasmolin I (C₂₁H₃₀O₃), pyrethrin II (C₂₂H₂₈O₅), cinerin II (C₂₁H₂₈O₅) and jasmolin II (C₂₂H₃₀O₅) (Parleviet and Brewer, 1971). Roncevic *et al.* (2014) the roots of pyrethrum plants were characterized by a combination of loadings of iron, aluminium, nickel, chromium, strontium, and barium, while the stems, leaves, and flowers showed more contributions from sodium, potassium, calcium, magnesium, phosphorus, sulphur, manganese and copper. They have also observed that microelements such as copper, aluminium, and iron were more readily transferred into natural insecticide extracts. Rehman *et al.* (2014) stated that pyrethroids are broadly classified into first and second generation pyrethroids. The first generation (Type I) pyrethroids are less toxic to mammals than the second generation (Type II) pyrethroids. Sujith *et al.* (2012) concluded that ethanolic extract of *A. pyrethrum* has been demonstrated to improve cognitive processes by enhancing memory in different experimental paradigms. They have suggested that ethanolic extract of *A. pyrethrum* increased brain cholinesterase level and hence it possess memory enhancing activity in scopolamine induced amnesia model by enhancing central cholinergic neurotransmission. Jalayer Naderi *et al.* (2012) mentioned biological activities of *A. pyrethrum* such as antibacterial, immune-stimulating and antioxidant, antidepressant. The most important pharmaceutical benefits of *Anacyclus pyrethrum* are presented in Table 2.

Table 2. Pharmaceutical benefits of *Anacyclus pyrethrum*

Benefits	Mechanism and impacts	Reference
Oxidative stress, neuroprotective effects and cognitive impairment	<p>a. The hydroalcoholic extract of <i>A. pyrethrum</i> (HEAP) root significantly prevented seizure induced oxidative stress and cognitive impairment in a dose-dependent manner.</p> <p>b. HEAP also normalized the decrease in cholinesterase activity caused by seizures.</p> <p>c. The ethanolic extract of <i>A. pyrethrum</i> increased brain cholinesterase level, so it possesses memory enhancing activity in scopolamine induced amnesia model by increasing central cholinergic neurotransmission.</p> <p>d. <i>A. pyrethrum</i> extracts attenuated the neuronal activation caused by kainic acid injection in hippocampus; its extracts exhibited neuroprotective following kainic acid injection in hippocampus.</p>	Pahuja <i>et al.</i> (2012) Sujith <i>et al.</i> (2012) Manouze <i>et al.</i> (2019)
Natural pesticide	<p>a. The most outstanding properties of pyrethrum are rapid action of this insecticide, low mammalian toxicity, broad spectrum of activity, lack of insect immunity, lack of persistence and very effective insect repellent.</p> <p>b. The pyrethrum maybe a potential candidate for the impregnation of mosquito nets and textiles in areas where resistance to pyrethroids has become problematic.</p>	Greening (1983) Kimani and Sum (1999) Atkinson <i>et al.</i> (2004) Duchon <i>et al.</i> (2009)
Immunostimulant activity	a. The fractions from <i>A. pyrethrum</i> showed a marked stimulating impact on the reticuloendothelial and increased the number of peritoneal exudates cells, and spleen cells of mice.	Bendjeddou <i>et al.</i> (2003)
Anticonvulsant and neuro-pharmacological activity		Zaidi <i>et al.</i> (2009)
Lowering Blood sugar	a. The aqueous root extract of <i>Anacyclus pyrethrum</i> significantly reduced elevated blood glucose level in Alloxan diabetic rats without showing any hypoglycaemic effect in normal rats.	Tyagi <i>et al.</i> (2011)

Immunomodulatory activity	<i>A. pyrethrum</i> can be considered as an adaptogen and immunomodulator in the Ayurvedic system of medicine.	Sharma <i>et al.</i> (2010a)
Anti-cancer activity	a. The <i>A. pyrethrum</i> extract significantly inhibited the cell growth, and it can successfully induce apoptosis in cancer cell line (HCT) cells; therefore, it could be used as a novel therapeutic candidate for colorectal cancer treatment.	Mohammadi <i>et al.</i> (2017)
Anti-inflammatory activity	a. The methanol extracts of roots are non-toxic substance, and can be used in the treatment of pain and inflammatory disorders in humans.	Rimbau <i>et al.</i> (1996) Manouze <i>et al.</i> (2017)
Antioxidant activity	a. <i>A. pyrethrum</i> is a procumbent herb of immense medical value, largely due to the presence of an array of therapeutically active alkaloids such as pellitorine with antioxidant activities.	Singh <i>et al.</i> (2020)
Antimicrobial activity	a. Essential oils from the aerial parts of <i>Anacyclus pyrethrum</i> showed activity against <i>Candida albicans</i> and <i>Staphylococcus aureus</i> bacteria strains. b. <i>A. pyrethrum</i> has antimicrobial activity against the tested microbial species except <i>E. faecalis</i> and <i>S. typhimurium</i> .	Selles <i>et al.</i> (2013) Canli <i>et al.</i> (2017)
Improve sexual parameters	a. It may improve sexual parameters, and it can also prolong effect and capacitate the treated rats for improved sexual potential.	Sharma <i>et al.</i> (2010b) Haghmorad <i>et al.</i> (2019)

Conclusions

Pyrethrum (*Tanacetum cinerariifolium*) is a small perennial plant cultivated for extraction of pyrethrins from dried flower achenes. Pyrethrum flowers are used for the extraction of an important insecticide, the pyrethrins, which is non-toxic to humans and other warm-blooded animals. Pyrethrins are the active ingredients derived from the natural insecticide pyrethrum, and pyrethroids are synthetic or manufactured versions of pyrethrins. The active constituents of pyrethrins are, Pyrethrin I, Cinerin I, Jasmolin I, Pyrethrin II, Cinerin II and Jasmolin II. The combined usage of pyrethrin I and II have significant influence for pest control. Because, the human population is exposed to chemical pesticides which can lead to long term health hazards, the final goal of farmers should be at reducing consumption unnecessary pesticides and replacing chemical products with alternative organic and natural products to protect agricultural crops against insects. Organic farmers can use pyrethrins as an insecticide for fruit and vegetable crops. Pyrethrum can control pests in a difficult battle in a natural way. The roots of the plant *Anacyclus pyrethrum* DC are reported to have good medicinal value in traditional and modern system of medicine. The plant mainly contains alkaloids, tannins, triterpenes, flavonoids, sterols, some trace metals and phenols. *N-alkylamids* and ester pyrethrine are the main constituents of roots which have tremendous medicinal values. *Anacyclus pyrethrum* has various activity such as anti-bacterial, anti-fungal, anti-diabetic, anti-oxidant, anti-convulsant, anti-depressant, anxiolytic, inhibit release of acetylcholinesterase enzyme, aphrodisiac, anabolic, reproductive, immunological active polysaccharides and memory enhancing activity. This herb is useful for various diseases, but the most important ones are diabetes, anabolic, Alzheimer and aphrodisiac. Herbal remedies and other nutraceuticals are increasingly and extensively used by a substantial part of the population. Treatment with natural herbal medicines and organic insecticide and non-synthetic drugs are recommended.

Authors' Contributions

All authors contributed equally to this research, such as data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, validation, visualisation, writing review and editing. All authors read and approved the final manuscript.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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