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Pyrethrum, Chrysanthemum cinerariiaefolium (Trev.) as Source of Natural Pesticide

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SUMMARY

Pyrethrum Chrysanthemum cinerariiaefolium is an herbaceous perennial plant having white flower heads, lobed leaves, with numerous and fibrous shallow root system. The flower contains pyrethrins which are localized in the secretory ducts of the achenes. The pyrethrins undergo decomposition when exposed to sunlight. Pyrethrins are environment friendly and not toxic to beneficial insects. They contain Pyrethrin I, Pyrethin II, Cinerin I, Cinerin II, Jasmolin I and Jasmolin II. They have knock down action and are effective against a wide range of sucking pests. Here, we give a gist of various effects, composition and mode of action of the natural pesticide pyrethrin.

INTRODUCTION

Pyrethrum *C. cinerariiaefolium* is a perennial plant belonging to the family Asteraceae that has been widely used for the production of pyrethrin (Moslemi *et al.* 2018). The plant derived pesticides can be less toxic both to mammals and the environment that increases the use of pyrethrum (Shahrajabian *et al.* 2020). Insecticidal pyrethrins are extracted from the achenes within the flower heads and represent the economically most important natural pesticide which are neurotoxins effective against a wide range of insect pests, and broadly applied in private homes, gardens, stables and organic agriculture, because of their environment friendly properties (Yang *et al.* 2014). About 200 years ago, it was discovered in central Asia. The first record of the pyrethrum was 2000 years ago at the time of China's Chou Dynasty. 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 *C. cinerariiaefolium* found in Dalmatia which is part of Croatia. Pyrethrum's insecticidal properties were recognized in the middle of the 19th century. The earliest cultivation of pyrethrum, also called Persian pyrethrum or Persian powders, was in the region of the Caucuses 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*. On a dry weight basis a pyrethrum inflorescence contains the majority of the plant's active compounds, reported in the range 1-2% pyrethrins (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 (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 plant

The pyrethrum plant of commerce is the daisy *Tanacetum cinerariiaefolium* or *Pyrethrum cinerariiaefolium* or *C. cinerariiaefolium*. It is a white flower headed, tufted perennial herbaceous plant of the family Compositae. The plant possesses deeply lobed leaves, with numerous and fibrous shallow root system (30 cm). The pyrethrum flowers were first produced commercially in Armenia in 1828. 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. The plant requires soils rich 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). These are cultivated near the equator, from 1800 to 4000 m in altitude, and with rainfall of 50 to 200 cm spread throughout at least seven months of the year. Under these growing conditions, flowering continues for seven to eleven months each year. The pyrethrins are localized in the secretory ducts of the achenes, where they are protected from photodecomposition and isolated. So, they are not toxic to insects feeding on or visiting pyrethrum flowers. 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.* 2018).

C. cinerariiaefolium

T. cinerariiaefolium

Method to purify pyrethrum extracts

The pyrethrum flowers are handpicked when four or five rows of disc florets are open, and each flower contains about 3 to 4 mg pyrethrins. After drying in the sun or mechanically, the flowers are grounded and extracted with hexane. Evaporating the hexane yields a dark, viscous oleoresin concentrate containing about 30% pyrethrins. The concentrate is either diluted with plant or mineral oil to 25% pyrethrins (oleoresin extract) or purified by methanol extraction and charcoal treatment to produce a dewaxed and decolorized refined extract. This purification removes components which earlier gave allergic responses evidenced as dermatitis in humans sensitive to rag weed pollen.

Relative proportions of the sex esters in a typical 50% extract of pyrethrum

Cinerin I: 3.70%, Jasmolin I: 2.00% Pyrethrin I: 19.00% (Pyrethrins I: 24.70%)
Cinerin II: 5.80%, Jasmolin II: 2.00%, Pyrethrin II: 17.50% (Pyrethrins II: 25.30%)

Pyrethrin analogs with specific chemical groups

Allethrin: Allyl analog
Phenothrin: Phenoxy analog
Tetramethrin: Tetrahydrophthalimidomethyl analog

Pyrethrin analogs by Michael Elliott *et al.*

Resmethrin: Discovered at Rothamsted Experimental Station
Permethrin: Enhanced persistence
Cypermethrin: Cyano analog of permethrin
Decamethrin: Deca (10)-fold more potent

Other origins

Kadethrin: Knockdown analog of pyrethrin
Fenvalerate: A phenylisovalerate pyrethroid

Common names of natural esters and synthetic analogs and origin or possible origin of names

Name of Natural materials	Origin
Pyrethins	*Pyrethrum cinerariiaefolium* (old genus name)
Pyrethrin I	Derived from chrysanthemum monocarboxylic or chrysanthemic acid
Pyrethrins II	Derived from methyl ester of chrysanthemum dicarboxylic, *i.e.*, pyrethric acid Pyrethrins and related cyclopentenolone derivates
Rethrins	Pyrethris and related cyclopentenolone derivates
Cinerins	*Tanacetum cinerariiaefolium*
Jasmolins	Similar structure to jasome from *Jasminium grandiflorium*

Properties of pyrethrum

- Rapid mode of action
- Low mammalian toxicity
- Broad spectrum of activity
- Lack of insect immunity
- Lack of persistence
- Very effective insect repellent

Mode of action of pyrethrins

Pyrethrum has knockdown action. Pyrethrin I and II has knockdown action effect whereas Cinerin I and II kills. It prevents the closure of voltage gated Sodium channels and thus inhibiting the actional transmission.

Products of pyrethrins

- Indoor bugbombs or foggers
- Human head lice treatments
- Pet flea sprays
- Dragon
- Drione
- Pyrenone
- Pyrocide

Uses of pyrethrum extract

Pyrethrum extract is used for the control of pest insects in the household, in barns and in stored products and for direct application to man and livestock. Before the Second World War, powdered pyrethrum flowers or pyrethrum extract were employed for the control of agricultural and horticultural insect pests. The pyrethrins knock down house flies, mosquitoes and other flying insects rapidly and at appropriate doses, the insects die a few minutes or hours later. It repels and disorients biting flies and mosquitoes which therefore bite less frequently. It flushes cockroaches from their hiding places to contact lethal doses of the insecticide.

Three developments helped to establish and maintain these uses for pyrethrum. The first was an alternative method for delivering pyrethrins to control mosquitoes by incorporating ground pyrethrum flowers with other ingredients into mosquito coils, which, burned throughout the night, generated a smoke that repelled, expelled, knocked down, or killed mosquitoes in human habitats. The second in 1941 was the aerosol can or "bomb" which is used to disperse many types of household and industrial agents, was originally perfected to deliver pyrethrum extract. It produces droplets below 30 um in diameter, essential for maximum effectiveness and economical use of the pyrethrins. The final development was an additive or synergist, piperonyl butoxide, which was discovered in 1949. Although essentially noninsecticidal, it increases the potency of pyrethrum by more than fourfold when added at two to ten parts of synergist per part of pyrethrins. The pyrethrins synergist combination is much more economical than the insecticide alone, since the synergist costs less than 5% per unit weight of the pyrethrins. The synergist also increases the likelihood that insects knocked down will subsequently die rather than recover. In addition to piperonyl butoxide, another type of synergist, MGK 264, has also been important for many years.

Pyrethrum is generally considered to be the safest insecticide and was labeled as "nontoxic to humans and pets." This labeling is no longer allowed, so it is difficult for the user to differentiate the relative safety of various household insecticide products. After use for more than a century, there are very few cases of human illness associated with exposure to pyrethrum and most of these are early reports of dermatitis or allergic reactions due to impurities no longer present in the purified extract. Pyrethrins were once used at three consecutive daily doses of 10-20 mg per adult or 5 to 10 mg per child to control intestinal worms without reported ill effects.

The pyrethrins are very unstable in light and air, limiting the areas where they are effective but also providing a safety factor against the accumulation of hazardous residues. Uses of pyrethrum and its synergists are regulated by restrictions under the Environmental Protection Agency and by tolerances for levels in food and feed under the Food and Drug Administration. The tolerance values for postharvest applications to various plant products are commonly 1-3 ppm for pyrethrins and 8-20 ppm for piperonyl butoxide. In several cases, these compounds are exempted from the requirement for tolerances because of their safety relative to the levels likely to be present under normal conditions is acknowledged.

Effects of pyrethrins

I. Animals

- Pyrethrins are one of the least poisonous insecticides to mammals
- Rats fed high doses (1,000 milligrams per kilogram of body weight or mg/kg) of pyrethrins showed liver damage
- Rats exposed to pyrethrins exhibited difficulty or rapid breathing, incoordination, sprawling of limbs, tremors, aggression, and sensitivity to external stimuli, twitching and exhaustion
- Various extracts from pyrethrum flowers have caused allergic contact dermatitis in sensitized and unsensitized guinea pigs. The commercially refined extract, which is present in insecticides today, did not produce any allergic reactions in guinea pigs
- Sensitization sometimes occurs in some individuals after a single exposure which causes either an asthmatic condition or a skin rash or inflammation. After the initial exposure to the sensitizing agent, the sensitized individual responds to a dose smaller than the initial dose.
- Pyrethrins are low in toxicity to mammals because they are quickly broken down into inactive forms and pass from the body in the urine and faeces
- Rabbits fed moderate doses (up to 90 mg/kg) of pyrethrins during a sensitive period of pregnancy had normal litters. Rats fed very high doses (5000 mg/kg) of pyrethrins for three weeks before their first mating produced low birth weight pups. There were no birth defects in pups of rabbits exposed to pyrethrins

II. Humans

- Inhaling pyrethrins can cause coughing, wheezing, shortness of breath, runny or stuffy nose, chest pain or difficulty breathing
- Skin contact can cause a rash, itching or blisters
- A person with a history of allergic contact dermatitis experimentally exposed to crude pyrethrum developed contact dermatitis
- Pyrethrum may be absorbed by the digestive tract and the lungs. However, it is poorly absorbed through the skin. Based on animal studies, any amount of pyrethrins absorbed by humans would be expected to be rapidly excreted.

III. Wildlife

- Pyrethrins are highly toxic to fishes and tadpoles. They affect their skin touch receptors and balance organs
- Pyrethrins are toxic to beneficial insect such as honeybees and many aquatic invertebrates
- Pyrethrins are low in toxicity to humans, other mammals and birds
- Pyrethrins are not reported to cause reproductive problems or birth defects

CONCLUSION

As pyrethrum is not toxic to beneficial insects and don't leave any residues in the environment, these are widely used in organic farming for the management of pests. Pyrethrum is extracted from the daisy plant *C. cinerariifolium* from dried flower achenes. 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 most important properties of pyrethrum are raid 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. 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 of 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 natural way.

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