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Review Article

Ethno-pharmacological review on the wild edible medicinal plant, *Lilium martagon* L

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Abstract

Purpose: *Martagon lily (Lilium martagon L.) is used in Eastern traditional medicine for wound healing and treatment of toothache. This review is intended to provide a comprehensive and critical evaluation of the chemical, botanical, ethnological, pharmacological, and pharmacognostic aspects of L. martagon, with a view to facilitating further in-depth pharmaceutical studies on the potentials of the plant as a herbal remedy.*

Methods: *Diverse electronic search engines and specialized reference tools such as Google, Google Scholar, Scopus, Web of Science, scientific literature, publishing sites and electronic databases (Pubmed, Springer, Wiley and Science Direct) were used for data retrieval. The data focused on botany, traditional uses, biological activities and phytochemistry of L. martagon, with emphasis on integration of this plant in official medicare.*

Results: *Lilium martagon possesses anti-inflammatory, sedative, anticancer, analgesic and hemostatic properties. Some modern techniques (in vitro propagation, genetic manipulation and advanced molecular biology techniques) have been applied in L. martagon biotechnology, with respect to major plant diseases and genetic variation issues.*

Conclusion: *Lilium martagon L contains different groups of biologically-active substances, amongst which are pyrroline derivatives and steroidal saponins. These may justify the usage of this plant and its subspecies in the traditional treatment of a wide spectrum of diseases.*

Keywords: *Lilium martagon, Pyrroline derivatives, Lilidine, Jatropham, Steroidal saponins, γ-methylene glutainic acid*

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INTRODUCTION

Lilium martagon L., syn. *Lilium versicolor* Salisb. (martagon lily [1] or Turk's cap lily), is a representative of Eurasian lily species, genus *Lilium* consisting of approximately 100 species. It is native to a widespread area covering the Portuguese Republic, the whole Europe and Asia region, and Mongolia in the Far East [2]. Numerous names have been suggested for

varieties and subspecies of the plant. However, only two of these names are considered by the World Checklist [3]. The name “Turk's cap lily”, also related to several other species, came from the characteristic shape of the petals. “Martagon” is a specific epithet, a Turkish word that also means cap or turban [4]. Other names are “royal curls” (“carskie kudri” in Russian) [5], and “sarana” [6]. The systematics of the *L. martagon* forms includes the names: *L. caucasicum* (Miscz. ex Grossh.) Grossh, Caucasian lily [= *L. martagon* var. *martagon*], *L. martagon* subsp. *caucasicum* Miscz. ex Grossh. [= *L. martagon* var. *martagon*], *L. martagon* ssp. *pilosiusculum* (Freyn) Miscz. ex Iljin, *L. martagon* ssp. *sooianum* Priszter, and *L. martagon* b. *pilosiusculum* Freyn [7,8].

The juice of the bulb of martagon lily has for long been used as a medicinal plant in traditional medicine in China, Tibet, Mongolia, Buryatia, Yakutia, Siberia, and the Far East, for wound healing, and as infusion for treating toothache [8]. Traditionally, *L. martagon* has food value: it is consumed raw, or in the boiled, fried or dried state, and as a seasoning [9]. The bulbs are edible. In Siberia, they are eaten raw or baked in hot ash, or boiled with milk and butter. The dried bulbs of this plant and other species of lilies are used by Yakuts in the flour form for cooking milk porridge, and Kyrgyz use the bulbs to season sheep cheese [10]. Cultivars of lily martagon have for long been used in ornamental gardening [11-13].

METHODS

Diverse electronic and scientific search engines, and specialized reference tools such as Google, Google Scholar, Scopus, Web of Science, scientific literature, publishing sites, electronic databases (Pubmed, Springer and Wiley and Science Direct) were used in the search for relevant literature. In addition, a systematic search in online research libraries such as E-library and specific ethnopharmacological publications was carried out in order to get exhaustive data on the medicinal uses of *L. martagon*.

FINDINGS

Botanical characteristics of *L. martagon*

Lilium martagon is widely distributed in the area from Europe to North Asia. The habitat of *L. martagon* is the mountainous area located in the European part of Russia, in the Carpathians, in Transcarpathia, and in the south of Western and Eastern Siberia. It grows on the slopes of mountains, and on edges, glades and meadows. *Lilium martagon* occurs singly in mixed, deciduous and small-leafed forests on rich medium-moistened soils in the mountains – from the lower to the upper mountain belt [8]. It grows individually in mixed, broadleaf forests, glades and forest edges, among shrubs in dense grass stand, but does not form continuous dense stands anywhere [14].

Lilium martagon is a perennial herb that grows up to 30 to 150 cm in height (occasionally it reaches 200 cm). The bulb is about 8 cm in diameter [15]. It is formed by yellow fleshy scaly leaves. The stem is round, usually with red spots. Oblong median leaves are collected in whorls of five or six pieces, with the next leaves located higher along the stalk. The lanceolate leaves are about 15 cm long and 5 cm wide, with smooth edges. The flowers are drooping in few-flowered racemes. Flower diagram is $*P_{3+3}A_{3+3}G_{\underline{(3)}}$. The perianth is purple with dark purple spots. However, sometimes, *Lilium martagon* plants with varied colors are seen – from white to almost black. The perianth segments are 3 - 4 cm long, and are bent back from the base. The stamens are with purple anthers. Blooming occurs yearly from June through July. In an open place (on a sunny glade), for example, up to twenty flowers are formed on a plant.

The fruit is a six-sided capsule. The seeds are triangular and flat, with membranous edges, and light or dark brown in color, 7.88 ± 0.76 mm long and 6.05 ± 0.49 mm wide, with endosperm. The germ is cylindrical, straight, and poorly differentiated [8,16-19]. The pollen grains have a single furrow, with length of 59.2-85.7 μ, width of 37.7-60.3 μ, furrow width of 8.6 - 15.9 μ, and exine thickness of 1.4 - 2.5 μ [20]. The chromosome number of *L. martagon* is 2 n = 24 [21].

Interestingly, the fusion of one sperm cell with an egg cell for formation of embryo, and fusion of another sperm cell with a polar fusion nucleus to form endosperm (double fertilization) was discovered in lily plants in 1898, especially in *L. martagon* and *Fritillaria tenella* M.Bieb. (*Fritillaria orientalis* Adams) [22]. The formation of the sexual nuclei was described by Sargant in 1896 -1897 [23,24].

Lilium martagon ssp. *pilosiusculum* (Freyn) Miscz. ex Iljin differs from its close European species *Lilium martagon* L. by lanceolate (not reversely ovoid) leaves, and lanceolate (not linear) bracts, which, like the sepals, are strongly pubescent [12]. Numerous martagon lily hybrids with various flower colors are known [25-27].

Figure 1: *Lilium martagon* L.: (1) upper part of the stem, inflorescence with floral diagram in flowering period; (2) upper part of the stem and capsule after flowering period; (3) seeds; and (4) closed bulb with roots [8,33].

Genotype characteristics of *L. martagon*

Genetic variations within Sweden populations and relatedness among *L. martagon* populations have been estimated using random amplified polymorphic DNA (RAPD) markers. The studied populations were unexpectedly heterogeneous, notwithstanding the limited population size. There is a remarkable correlation between gene diversity and population size: larger populations have higher gene diversity level than smaller populations. Domesticated *L. martagon* has high levels of intra-population variability [28]. European lilies (including martagon section) were investigated for molecular phylogeny and DNA levels. Different sections were easily distinguished with rpS4-trnT-trnL, ITS sequences and assessments of genome size, whereas an exceedingly low genetic differentiation was found at a sub-sectional level [29]. Genotype diversity varied according to distribution and location [30].

Composition of biologically-active compounds in *L. martagon*

The chemical composition of the martagon lily has so far not received much research attention. The presence of alkaloids in all parts of the plant, as well as saponins and flavonoids in the aerial parts, have been established. The bulbs contain large amount of proteins, mucous substances, vitamins, sugars, iron and boron [31-33].

Lilidine, syn. jatropham (**1**) (5-hydroxy-3-methyl-1, 5-dihydro-pyrrol-2-one) was isolated from the epigeal part of *L. martagon* in 1987 (Figure 2) [36,37]. Studies on the total alkaloid content (TAC) of *L. martagon* plants growing in the high-mountain part of South Urals [Kuyantau (Malyi Yamantau) region] revealed values of 0.0063 – 0.160 % in the aerial part, and 0.150 – 0.358 % in the bulbs, with maximum TAC at the beginning of vegetation period (April) [35].

In underground and aerial parts of the plant, γ-methylene glutamic acid **(2)** is accumulated at the highest concentration, as revealed from TLC analysis of plants at different vegetative periods (at initial growth period, during growth, at the beginning of flowering, and flowering statge) in Cuneo (Italy) in the spring-summer period [36].

Researchers (TUPLS, Tokyo, Japan) have isolated several compounds from the methanol extracts of L. martagon fresh bulbs using e chromatographic separation technique. These compounds are 3,6'-di-O-feruloyl sucrose (**3**), (2S)-l-O-caffeoyl-3-O-β-D-Glkglycerol (regaloside C) (**4**), jatropham (**1**), jatropham 5-O-β-D-Glk (**5**) and jatropham 5-O-[O-β-D-Glk-(1→3)-β-D-Glk (**6**); phenylpropanoid ester of a pyrroline derivative (–)-5-hydroxy-3-methyl-3-pyrrolin-2-one 5-O-(6-O-p-coumaroyl-β-D-Glk) (**7**), and two new steroidal saponins (25S)-spirost-5-ene-3β,17α, 27-triol 3-O-{O-β-D-Glk-(1→2)-O-β-D-Glk-(1 →4)-β-D-Glk} (**8**) and (25S)-5α-spirostane-3β,17α,27-triol 3-O-{O-β-D-Glk-(1→2)-O-β-D-Glk-(1→4)-β-D-Glk}(**9**) [37-39].

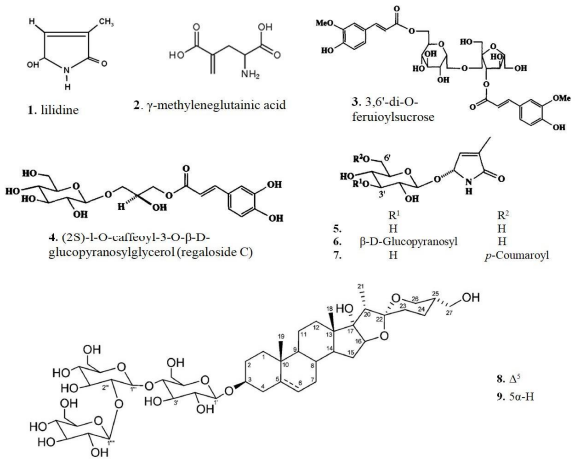

Figure 2: Structures of compounds isolated from *L. martagon*

Caffeic acid, limonene, indole carbinol, α-carotene-5, 6-epoxide, dioxin, and xanthophyll-related pigment were isolated from the pollen of *L. martagon* [39].

Biological activities and ethno-pharmacological uses of *L. martagon*

The bulbs, stems, leaves, and flowers of *L. martagon* are used as medicinal raw materials. The juice of *L. martagon* is used for the healing of external wounds and stomach ulcers. The bulbs are crushed and cooked with flour for use in opening of boils. Preparations of *L. martagon* have anti-inflammatory, sedative, analgesic and hemostatic properties, and are used for treating gynecological diseases. Lily bulbs are widely used for treating inflammation of the rectum and bladder, and as effective anti-hemorrhoidal agents. The flower infusion is used for treating gallbladder diseases [10]. Moreover, *L. martagon* is popular for its used in treating cancers [40]. Extracts of *L. martagon* are beneficial in the inhibition of melanin synthesis in skin epidermal tissues, and also for skin lightening [41].

The pollen grains of *L. martagon* are non-allergic, but in some cases, specifically when exposed to diesel particulate matter (DPM), they may cause symptoms of allergy in sensitized individuals. The DPM induces new allergenic proteins, carries allergen molecules, acts as adjuvant for allergens, and mediates particle agglomeration on the pollen surface [42].

Propagation methods and challenges in cultivating *L. martagon*

In garden practice, two diseases of lilies often occur. One of these diseases affects many types of lilies, and is caused by the microscopic fungus botrytis (*Botrytis ellyptica*) [43]. This fungus disease is often confused with a viral lily disease known as a lily mosaic virus [44]. The other disease is lily symptomless virus (LSV) which is manifested in stunting and symptom of interveinal chlorosis resembling a nutrient deficiency [45]. Clover phyilody phytoplasma was identified at the molecular level in *L. martagon* growing in West Bohemia, with appearance characterized by unusual malformation (very flattened stem) [46].

Martagon lilies are being grown with traditional methods (bulbs and seeds) and biotechnology methods. Cultivation of *L. martagon* from the **b**ulb is a very slow process, and it can produce only 3-5 plants from one bulb. In contrast, cultivation from the seeds provides growing lilies more easily and in greater amounts; hundreds of seeds can be obtained from a single lily [47].

Parts of *L. martagon* bulbs (nail-like scales) have meristematic reproduction ability and can be used for breeding purposes [48]. Tissue culture has become successful as an alternative to vegetative reproduction, and the plant can be grown using modern plant tissue culture methods [11].

Some modern techniques such as *in vitro* propagation, genetic manipulation and advanced molecular biology techniques in plant biotechnology have been successfully implemented in martagon lilies [55-58]. These techniques make it possible to propagate and produce new phenotypes. Efficient *in vitro* culture protocols allow for quick multiplication of lilies and accelerate breeding programs [62-65]. In view of the fact that *L. martagon* is an endangered species [63], it has been successfully propagated using callus culture by somatic embryogenesis. Besides, modern *in vitro* culture methods play a critical part the protection of this rare species [64]. Different strategies for cryopreservation of the seeds have been proposed for protecting *L. martagon* plants *ex situ* [65].

CONCLUDING REMARKS

Lilium martagon possesses different groups of biologically-active compounds such as alkaloids, flavonoids, steroidal saponins and amino acids. Herbal drugs prepared from *L. martagon* possess anti-inflammatory, sedative, anticancer, analgesic and hemostatic properties. To establish the relationship between chemical composition of *L. martagon* and its pharmacological effect, more studies need to be carried out. It is expected that this plant with a rich history of traditional medicinal usage and great potential, will soon take its place among the pharmacopoeial species.

DECLARATIONS

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Conflict of interest

No conflict of interest is associated with this work.

Contribution of authors

We declare that this work was done by the authors named in this manuscript, and all liabilities pertaining to claims relating to its content will be borne by the authors. All authors equally contributed to this review.

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