Biological and Chemical Diversity of *Angelica archangelica* L.

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Garden angelica (*Angelica archangelica* L.), native to the northern temperate region, is widespread in Europe and Asia. Since the middle ages, it has been used for healing and as a vegetable in traditional dishes. In the modern era, it has been proven that *A. archangelica* has a complex chemical composition. The main derivatives that contribute to the plant's biological activities are essential oil and coumarins.

angels root Apiaceae Garden angelica

1. Introduction

Angelica archangelica L. (syn. *A. officinalis Hoff.*), garden angelica, or The Root of the Holy Ghost, is a well-known medicinal plant with doubtful native range, but best known as Norwegian angelica. Distribution is limited to the northern temperate region of Europe, from Northern Fennoscandia to Eastern Siberia, and the natural habitat of this plant extends up to the Himalayas, while it is cultivated in most other regions [1][2][3]. It mostly grows in moist places in the mountains and in mountain valleys. It can be found in the lowlands of the far north [4]. It was highly valued in the Middle Ages and traded to Continental Europe by the Vikings as food (for flavoring liqueurs and aquavits, omelets, trout, to be made into jam, and as a preservative for reindeer milk) and a medicinal plant (as a calming remedy for treating hysteria, seizures, hypertension, rheumatism, and biliary diseases, as well as plague) [2][5][6]. It is known that this plant was associated with the magic of protection against evil spirits and witchcraft, as well as for healing [7][8][9]. Furthermore, the whole plant can be used as a vegetable (roots, young shoots, leaves, and seeds) if harvested appropriately [10].

In Europe, apart from Nordic countries (Finland, Sweden, Norway, Denmark, Greenland, the Faroe Islands, and Iceland), *A. archangelica* is cultivated in Poland, Germany, the Netherlands, Belgium, France, Austria, Hungary, and Romania, while it is often grown in Asia in Central Russia, as well as in India and Thailand [11][12][13][14][15][16]. In Serbia, *A. archangelica* is a rare plant in natural and semi-natural habitats [17]; however, due to good prices and the constant demand for essential oil, there is considerable interest in cultivating this essential-oil-bearing crop [18][19].

2. Biological Characteristics

Angelica archangelica L. 1753 is a bi-annual or perennial plant from the Apiaceae family. In the first year of growing, it produces a rosette of large (30–70 cm in length), compound leaves with a hollow, tubular leaf stalk.

During the first year, it accumulates nutrients in long, spindle-shaped, thick roots with a yellowish–grey epidermis. If the fresh root is bruised, it oozes honey-colored juice. In the second year, it forms erect flower stalks, up to 2 m tall, with ridges and grooves, hollow and tinged with purple, not glaucous. Basal leaves are huge, two-pinnate, and glabrous. Cauline leaves are two-pinate with petioles strongly sheathed at the base, while upper leaves are reduced to inflated sheaths, which enclose the development of inflorescences, of the umbel type. Umbels are spherical (10–15 cm or more in diameter), with greenish–white flowers. It is a self-pollinated plant. Fruit is a schizocarp consisting of two mericarps, oblong, slightly dorso-ventrally flattened, glabrous, with prominent and acute dorsal ridges and developed marginal wings. The monocarpic plant wilts and dies after seed maturation. If the flowering stem is gathered before flowering and seed maturation, the plant's lifetime is prolonged (perennial). When damaged, the whole plant emits a strong aromatic scent, which could be described as terpenic, fresh, celeriac, and sweet [2][3][4][8][20][21][22].

The native range of the species covers the northern temperate region of Europe and Asia, from Northern Fennoscandia to Eastern Siberia, and the natural habitat of this plant extends up to the Himalayas. In the native range, the species are distributed along riverbanks and coastal zones, moving towards higher altitudes, where it also prefers moist or wet habitats [1][23][24][25][26].

Genus Angelica comprises 15 species with distribution in Europe and the Mediterranean, while in Serbia, five are present [17][27]. Among them, *Angelica archangelica* stands out as well known in folk medicine as angel root, primarily due to its traditional medicinal use. Within the species *A. archangelica*, more infraspecific taxa have been identified over time [28]. According to modern taxonomic treatment, three subspecies are accepted within the species *A. archangelica* subsp. *archangelica, A. archangelica* subsp. *litoralis* (Fr.) Thell, earlier known as *A. litoralis Fr*., and *A. archangelica* subsp. *decurrens (Ledeb.) B. Fedtsch*., formerly accepted as a species [29]. The populations from the Himalayas are recognized as taxon *A. archangelica* subsp. *himalaica* (C.B.Clarke) G.Singh & G.M.Oza [30]. Although numerous authors have lately classified populations from the Himalayas as A. angelica subsp. *archangelica* var. *himalaica* [29], differences in fruit size and the chemical composition of the root essential oil, followed by the geographical isolation of the population, indicate that it should be treated as a subspecies *A. archangelica* subsp. *himalaica* (C.B.Clarke) G.Singh & G.M.Oza, or eventually species, *A. himalaica* Clarke, due to geographical and ecological isolation. Further investigations need to be conducted to resolve this taxonomical and nomenclature problem. In addition, it is noted that a correlation exists between habitat preferences and fruit morphology, i.e., the smallest fruits are characteristic for subsp. *litoralis* (distributed at the seashore), followed by subsp. *archangelica* (distributed in continental and mountain regions), while the largest are in the populations from the Himalayas [22][30].

Contrary to some authors, who describe some characteristics as useful for Angelica species identification, followed by studies in which even subspecies can be clearly distinguished, [22][31][32], there are also scientists who claim that the genus Angelica has highly variable morphological traits, which leads to difficulty in recognition of both species and infraspecific taxa [21][33][34]. By comparing the native range of the above infraspecies taxa, geographical separation in four areas is noticeable. On the other hand, considering that Central Europe (excluding Poland, which belongs to the native range of species), moving further south and southeast, is treated as an arched area

for *Angelica archangelica*, overlapping distribution areas of European subspecies in this region support the given taxonomic approach [27][35][36][37].

Nowadays, it is valued primarily as a cultivated species, often used as a medicinal herb. In Southern and Southeastern Europe, both subsp. *archangelica* and subsp. *litoralis* are recorded as cultivated and as naturalized along river banks or in moist forests [17][21][31][35][36]. Since representatives out of cultivation are rare, it is not considered an invasive species, but rather a casual alien without or with a negligible impact on nature. This trait is important considering the need to grow this plant for pharmaceutical and medicinal use.

3. Chemical Composition and Biological Activities

A. archangelica has a complex chemical composition [38]. Apart from essential oil and coumarins, which contribute to the plant's biological activities [39], it contains glycosides, carbohydrates, phytosterols, saponins, phenols, fixed oil, and fats [40], which influence its nutraceutical potential [10].

Furanocoumarins (such as archangelicin, bergapten, xanthotoxin, imperatorin, osthole, and others) [41][42] are constituents responsible for the antibacterial, [43] antiviral, [44] anti-inflammatory, [45] antitumor [46][47], hepatoprotective, [48] antidepressant [42], and other activities, as well as for phototoxicity [49]. For these reasons, the European Medicines Agency (EMA) commission pointed out risks associated with furanocoumarins in preparations of *A. archangelica* [50].

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