3.2 Medicinal Plants of Central Europe

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Abstract

Medicinal plants cultivated and collected from wild nature in Central Europe play an important role in human life, and they are a regular part of people's everyday activity. Medicinal plants reach the market from three sources in Central Europe – from natural habitats (wild collected species), from cultivation, and from imported species. This text discusses the advantages and the problems of the cultivation and the wild collection of medicinal plants, as well as the current state and conditions of production of raw materials in the main Central European countries. The chapter includes detailed information about important European species – caraway (*Carum carvi* L.), chamomile (*Matricaria recutita* [L.] Rausch.), fennel (*Foeniculum vulgare* Mill.), and milk thistle (*Silybum marianum* [L.] Gaertn).

Keywords: medicinal plants, Central Europe, wild plants, cultivation, *Carum carvi, Matricaria recutita, Foeniculum vulgare, Silybum marianum*

Introduction

Herbs are still an important source of human and veterinary medicines, cosmetics, and seasonings. Historically, their collection, preparation and application were accompanied by a certain aura of mystery, and were grounded in religion and magic (Anglielczyk, 2011).

Nowadays, we can observe a change in a lifestyle of young people living in villages and small localities, which leads to traditional knowledge related to medicinal plants being forgotten. New generations find employment in cities, and move away from traditional forms of land farming. The multigenerational family model is increasingly becoming less frequent. All these factors cause the traditional use of plants and the rich customs associated with them to fall into oblivion (Szot-Radziszewska, 2005).

Political and economic changes, which have taken place in the late twentieth century in Central Europe, as well as a departure from central management policy in favor of local governments, have affected the life conditions of many people inhabiting non-industrialized regions or localities far from big cities. The proportion of unemployed and of people without the right to claim social assistance benefits has increased. Analysing the demographic situation, it appears that such people are of working age, and are physically fit, but are not capable of finding their place in the new reality. Agriculture on small surface areas has become unprofitable in a free market economy, as prices of agricultural products have to be competitive (Wolanski, 2013). Agriculture in Central Europe has become intensive and is now oriented to the production of the main commodities. The concept of reformed Common Agricultural Policy "towards 2020" (CAP) can contribute more to developing intelligent, sustainable and inclusive growth. The CAP must also take greater account of the wealth and diversity of agriculture in EU Member States. It can give a chance to traditional, local and sustainable production (European Commission, 2014).

Medicinal plants come to the market from three sources in Central Europe – from natural habitats (wild collected species), from cultivation, and from imported species (Ministry of Agriculture of the Czech Republic 2012). In comparison with other crops, MAPs are grown in confined areas ranging from a few square meters to thousands of hectares; the extent of cultivation depends on the needs of the processors (Ministry of Agriculture of the Czech Republic, 2012). Small-scale cultures reach at most 1 hectare (marshmallow – *Althaea officinalis*, pot marigold – *Calendula officinalis*), medium-scale cultures range from 1–5 hectares (marjoram – *Origanum majorana*, german chamomile – *Matricaria recutita*) and large-scale cultures cover more than 5 hectares (caraway – *Carum carvi*, milk thistle

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– *Silybum marianum*) (Nemeth, 2012). A great diversity is typical for MAPs and their growing guarantees an agro-ecological effect (species diversity within crop rotations). Also, the social and economic effect is significant. On the other hand, the cultivation of MAPs is very demanding; it requires higher proportion of manual labor. However, with MAPs, there is a limited use of mechanized technologies and a limited means of plant protection. The harvest and post-harvest treatment is labour-intensive (the most common basic treatment is drying) (Ministry of Agriculture of the Czech Republic, 2012).

The spectrum of wild species, collected from nature, is typical for individual countries and comes from past traditions. The raw material is cheap. However, there are some problems related to the collected drugs. The charges are small; it is difficult to record the documentation, and the plant material is heterogeneous. There is a risk of misidentification and pollution. In addition, the risk of attenuation of plant populations and the erosion of natural habitats has increased in general in the world (Nemeth, 2012). So there are many motivating factors for growing wild species. In the last decades, some important species were introduced in Central Europe (*Matricaria recutita, Tanacetum vulgare, Claviceps purpurea, Achillea collina, Verbascum phlomoides*) and many species are now in the process of the introduction (*Harpagophytum procumbens, Artcostaphyllos uva-ursi, Adonis vernalis, Artemisia annua, Verbena officinalis, Vitex agnus-castus*) (Nemeth, 2012).

Material and Methods

In Poland, MAPs are grown on more than 35 000 ha, of which 20 000 hectares are intended solely for the pharmaceutical and cosmetic industry, and the number of producers fluctuates at about 20 000 farms per year. They operate specialized and controlled plantations, according to the requirements set by contracts with food processing companies. The plantation area is 0.5–2.5 ha, depending on the species produced, and in the case of specialized farms, it reaches 6–10 ha. Approximately 70 species of medicinal plants are planted. The dominant species in Polish farms are milk thistle (*Sylibum marianum*), chamomile (*Chamomilla recutita*), caraway (*Carum carvi*), lovage (*Levisticum officenale*), peppermint (*Mentha piperita*), valerian (*Valeriana officinalis*), St. John's wort (*Hypericum perforatum*), and thyme (*Thymus vulgaris*). The plant processing companies purchase the vast majority of the material produced. Two thirds of the organized production is sold on the domestic market, and the remaining third is exported, mainly to European Union countries (Seidler-Lozykowska 2012; Spychalski 2013).

Hungary mainly produces poppy (*Papaver somniferum*) for the pharmaceutical industry. Other species include dill (*Anethum graveolens),* coriander *(Coriandrum sativum),* caraway (*Carum carvi),* fennel *(Foeniculum vulgare),* peppermint *(Mentha x piperita),* lemon balm (*Melissa officinalis*), milk thistle (*Silybum marianum*), valerian (*Valeriana officinalis*), savory (*Satureja hortensis),* thyme *(Thymus vulgaris),* chamomile *(Matricaria recutita),* oregano *(Origanum* spp.), St.John's Wort (*Hypericum perforatum*), aniseed (*Pimpinella anisum*), *etc.* (FDA, 2004; Bernath & Nemeth, 2014). 60–70% of medicinal plant species (120–130 species) come from natural habitats. The main collected species are black elder (*Sambucus nigra*), stinging nettle (*Urtica dioica*), horsetail (*Equisetum arvense*), chamomile (*Matricaria recutita*), chestnut (*Aesculus hippocastanus*), and rose hip (*Rosa canina*) (Bernath & Nemeth, 2014). Hungary annually exports about 214 MAPs species (FDA, 2004).

Slovakia produces cultivated medicinal plants on approximately more than 2 000 ha and poppy on 1 500 ha. The main species are milk thistle (*Silybum marianum*) – 600–1 000 ha, plantain (*Plantago lanceolata*), chamomile (*Matricaria recutita*), pot marigold (*Calendula officinalis*), lemon balm (*Melissa officinalis*), peppermint (*Mentha x piperita*), sage (*Salvia officinalis*), sea buckthorn (*Hippophaë rhamnoides*), caraway (*Carum carvi*), and spice pepper (*Capsicum annuum* var. *longum*). The area of marjoram (*Origanum majorana*) has decreased considerably. The main collected species are rose hip (*Rosa canina*), chestnut (*Aesculus hippocastanum*), black doder (*Sambucus nigra*), linden (*Tilia cordata* and *Tilia platyphyllos*), yarrow (*Achillea millefolium*), agrimony (*Agrimonia eupatoria*) and wild thyme (*Thymus serpyllum*) (Habán & Otepka 2011; Habán *et al.*, 2014).

The most commonly grown MAPs species in the Czech Republic are poppy for poppy straw, milk thistle (*Silybum marianum*), caraway (*Carum carvi*), ergot (*Claviceps purpurea*), coriander (*Coriandrum sativum*), fennel (*Foeniculum vulgare* var. *vulgare*) and chamomile (*Matricaria recutita*). The most commonly collected species in the Czech Republic are rose hip (*Rosa canina*), stinging nettle (*Urtica dioica*) and black elder (*Sambucus nigra*). In 2011, medicinal plants were cultivated on 4 063 ha with the production of 3 381 t and a yield 0.83 $t.ha^{-1}$. In 2012 the production area increased to 4 177 ha. According to the association PELERO CZ, milk thistle (*Silybum marianum*) helped increase the area of medicinal plants in the Czech Republic. The spice plants were cultivated on 4 525 ha with the production of 3 635 t and a yield 0.80 $t.ha^{-1}$ in 2011. In 2012, spice plants were cultivated on 3 887 ha. The main species in this group is caraway (*Carum carvi*), which is an individual item in the research of the Czech Statistical Office (Ministry of Agriculture of the Czech Republic 2012).

Results and Discussion

Caraway (*Carum carvi* L.)

Caraway belongs to the family Apiaceae. It is one of the oldest plants used as a spice and medicine. It is grown for its aromatic fruits – achenes. To a lesser extent, the leaves are used in cooking as seasoning for salads, soups and sauces. Caraway is a desired cash crop, and its cultivation has a long tradition in European countries, except the Mediterranean.

Botany

Caraway is a facultative biennial herb with a taproot. The biennial form is found most often; one-year caraway grows in warmer areas (Southern Europe). A form with reduced length of the growing season (winter caraway) was obtained by means of plant breeding. The stems are straight, 30–120 cm high, sparsely branched, smooth or slightly corrugated. Ground and lower stem leaves are petiolate, with a narrowly elliptic blade, pinnatisect with linear segments. Upper-stem leaves are smaller and more simply structured, sessile to long. Flat inflorescence consists of umbels composed of 8–11 umbellets with 15–18 flowers (Fig. 1). The flowers are usually bisexual, rarely only male, usually white, rarely pink. The fruits are achenes (Fig. 2) of elliptical or ovoid shape, squeezed at the sides, with a thin splitting carpophore. Seeds are crescent-curved and pointed, with 5 raised ribs (Růžičková *et al.* 2012). It grows wildly in meadows, pastures and other grassy areas, on boundaries and edges of roads, in ditches, on rocky slopes and in fallows.

Cultivation

Caraway prefers semiarid areas with medium to light moist soils rich in nutrients, with soil acidity of pH 6–7.5. Caraway is an undemanding plant, but it needs a lot of light. For the biennial form, light influences the formation of vegetative organs and the foundations of generative organs in the first year (Procházka & Vrzalová, 1988).

As for water, caraway is very demanding during both vegetation years. Total rainfall affects the yield and the distribution of yield potential. Therefore, the harvest yield varies over the years depending on the weather. The best cultivated areas in terms of caraway production are low-lying areas in potato-growing regions where seed potatoes are not grown and also in marginal areas of beet-growing regions (Vaculík *et al.*, 2009).

1: *Caraway umbels*

Source: Králík, J.

The Composition of Caraway Achenes

The most important caraway ingredient is an essential oil, which makes up 3–7% of total weight. The use of this essential oil depends on its composition. The main component and also the carrier of odour is (S)-(+)-carvone (50–80%), while about 50% of the essential oil consists of (R)-(+)-limonene and other terpenes. During maturation, the proportion of carvone increases and the share of limonene decline. The drug also contains oil (10–18%), proteins (20%), carbohydrates and flavonoids, calcium, potassium, magnesium, phosphorus and β-carotene (Růžičková *et al.*, 2012).

2: *Caraway achenes*
Source: Šmirous, P.

Use and Effects

Aromatic achenes (Fig. 3) are used as seasoning for the preparation of pastries, meat dishes, cold meats and cheeses, as well as for the production of liqueurs. Caraway is used in pharmacies and traditional medicine, as it soothes adverse digestive tract mobility, prevents excessive gas, and bloating, and stimulates endocrine glands. It increases milk secretion and promotes expectoration of mucus in respiratory diseases. It can be also used to modify the unpleasant taste or smell of drugs.

In pharmacies, caraway is used for the preparation of aromatic oils, syrups and medicinal teas with anticonvulsant, bactericidal and fungicidal properties. As part of grassland growth, caraway increases the dietary value of animal feed. Seeds, oil cake and straw are highly prized animal feed supplements that support the production of milk, increase the digestibility of nutrients, reduce the flatulent effects of other feed, increase appetite and have a positive effect on overall metabolism and health. It is not suitable for dairy cows due to an unpleasant smell that it adds to the milk, and it is poisonous to birds. Caraway is also an important plant for grazing bees. Caraway roots and leaf rosettes are used mainly in the northern part of Europe as a vegetable containing vitamin C.

3: *Caraway achenes*
Source: Růžičková, G.

Chamomile (Matricaria recutita [L.] Rausch.)

Nowadays, chamomile is the most favored and used medicinal plant throughout the world. Phytotherapeutically, its inflorescences are useful and a substantial part of their curative effects is determined by its essential oil content and composition (Salamon, 2007; Singh, *et al.* 2011).

Botany

Chamomile belongs to the genus *Asterales*, to the Asteraceae family. Chamomile root is thin, winding, creepy, and short, branching at both lengths. The above-ground portion grows 0.10 to 0.90 m high, according to growing conditions. The leaves are alternate; they consist of close threadlike segments. The stem is branched. 100 or more flower heads (anthodia) are gradually created on one plant (Fig. 4). The outer line consists of a series of tongue-elongated, white pistillate flowers (12–18). Tubular bisexual flowers are spirally placed inside the anthodium and gradually develop. After fertilization, 0.7 to 1.5 mm long and 0.3 mm thick achenes develop. The weight of 1000 achenes is 0.046–0.052 g. (Salamon 2007). The whole plant contains essential oil. Essential oils in different parts of the plant have different compositions and effectiveness. In the anthodia, the essential oil is formed in essential oil ducts and glandular trichomes (Slavík & Štěpánková, 2004).

Many varieties of chamomile, which differ in content and composition of active substances, have been created thanks to varying environmental conditions (Salamon, 2007; Gosztola *et al.* 2010). Motl *et al.*, (1977) classified chamomile into five chemotypes with different efficiencies (Tab. II).

4: *Chamomile anthodia*
Source: Kralík, J.

II: *Basic types of chamomile according to the predominant component of essential oil*

Type	Main component	Main essential oil comp.	Occurrence
Chemovar A	bisabololoxids (mostly A)	Azulene	Czech Republic, Hungary, Poland, Germany
Chemovar B	bisabololoxide	Azulene, cis-en-in-dicycloether	Argentina
Chemovar C	α-bisabolol	No azulene or just traces	Bulgaria and some German varieties
Chemovar D	α-bisabolol and bisabololoxide 1 : 1	Moderate or lower amount of azulene	Serbia, Croatia, Macedonia
Chemovar E	α-bisabolonoxide A		Bulgaria, Turkey

Source: Motl *et al.*, 1977

Cultivation

Chamomile is a very adaptable plant, but its yields and in particular the composition of its essential oil depends on environmental conditions (Fig. 5). Chamomile is not demanding as for the warmth, it germinates at a temperature of 6–7 °C. Adult plants can withstand frost up to –30 °C. Chamomile emerges 7–10 days after sowing, after 30–40 days the leaf rosette which has up to 40 leaves is formed, and the plant begins to develop flowers. The optimum temperature during flowering is 19–21 °C. Rainfall during flowering is not welcome because it affects the possibility of harvest. Chamomile requires light for germination, which must be respected when preparing the soil. During the short-day period of the year, the plant has a bush-like character and a more uniform formation of inflorescence. The strength and composition of light are of great importance.

5: *Chamomile in double rows*
Source: Kocourková, B.

Light affects the amount of flowers, the drying ratio and the composition of the essential oil (Rumińska, 1983; Salamon, 2007, 2009). Highest yields are obtained on neutral to alkaline soils (pH 7.3 to 8.1). Chamomile thrives on light, but also on heavy soils. Nitrogen affects the overall content of essential oil and the formation of bisabololoxides (Letchamo, 1993). Potassium has a direct effect on the essential oil content; it increases the share of chamazulene in the essential oil and the creation of bisabololoxides. Phosphorus decreases the content of bisabolol, but increases the total oil content. The recommended dose of nutrients per ha is 20–40 kg of N, 15–20 kg of P and 66–100 kg of K according to the reserves in the soil. Chamomile (*Matricaria recutita* L.) may be considered as an economic crop for improving water use efficiency (Seidler-Lozykowska, 1999, 2000; Baghalijan *et al.,* 2011).

Chamomile Drug Composition

The chamomile drug is found in the flower heads with stems not exceeding 20 mm. The identified substances contained in chamomile are essential oils (usually 3–15 $ml.kg^{-1}$), coumarins, and flavonoids. The distilled oil is dark blue, green or yellow, depending on the prochamazulene content. Matricin as prochamazulene in chamomile oils is transformed to the blue-colored artifact chamazulene during the distillation process (Franz *et al.* 1986). The main components of the essential oils are (-)-α-bisabolol, bisabololoxide A, B, (-)-bisabolonoxide A]. Another component of the essential oil is chamazulene formed from matricine during steam distillation (Gosztola *et al.,* 2010; Rahmati *et al.,* 2011). The classification into these chemotypes was made by Motl *et al.* (1977) and later by Franz (1982, 1989a). A-bisabolol—(pro) chamazulene population was identified on the Iberian peninsula, while mixed populations containing chamazulene, bisabolol, and bisabololoxides A/B are most frequent in Central Europe, and prochamazulene-free bisabolonoxide populations are indigenous to southeast Europe and Asia Minor (Franz, 2000).

Effects

The drug has anti-inflammatory, antispasmodic and carminative effects. It is used in the form of infusions, tinctures, extracts, and as part of products for gastrointestinal complaints (gastritides, enteritides, colitis, flatulence, spasms) and menstrual problems. It can be used in steam inhalations for asthma, hay fever, catarrh and sinusitis. Externally, chamomile drug can also be used for baths, rinses, compresses or ointments for treating wounds (Wichtl & Bisset, 2001; Franke *et al.,* 2005).

The anti-inflammatory and anti-allergic activity is mainly caused by apigenin, chamazulene, cis-en-in-dicycloether and (-)-a-bisabolol (Orav *et al.,* 2010). Antiulcer activity has been demonstrated for (-)-a-bisabolol. Chamomile essential oil also has antifungal and antibacterial effects on Gram-negative bacteria. An anticonvulsant effect was observed with flavonoids, especially apigenin (Wichtl & Bisset, 2001). Chamomile is also used to treat patients given to the fury. Chamomile essential oils contain substances that may be responsible for allergic reactions. A number of publications and web resources describe the manifestation of allergic contact dermatitis caused by sesquiterpene lactones.

In a few cases, allergic reactions to chamomile were reported. The suspected allergen, sesquiterpene lactone anthecotulid, occurring in *Anthemis cotula* L., generally does not occur in the genus *Matricaria*. Chamomile is non-toxic, its use is not addictive and it does not have significant adverse effects. Long-term use could, however, lead to the failure of mucous membranes (Franke *et al.,* 2005).

Fennel (Foeniculum vulgare Mill., Apiaceae)

Fennel is mainly cultivated as a spice and medicinal plant for aromatic fruits (the achenes, Fig. 6), but also as a fresh herb (as a culinary herb) and as a flowering herb (for the distillation of essential oil). Two main types of fennel are cultivated: bitter fennel (*Foeniculum vulgare* var. *vulgare* Mill.), and sweet fennel, which prevails in Asia (*Foeniculum vulgare* var. *dulce* Mill.). Both types differ in essential oil content and composition, and in the color and size of the achenes (Růžičková & Kocourková 2012; GRIN Database 2014; Mansfeld Database, 2014). The achenes have a camphoric, anise-like odor with a slightly bitter-sweet taste.

In cookery, a vegetable, Bolognese fennel, is used [Foeniculum vulgare var. azoricum (Mill.) Thell.]. It has thick fleshy petioles.

Fennel probably originates in the Mediterranean area, and it is one of the oldest domesticated plants. It was cultivated in many countries from Europe to the Far East, and in sub-Saharan Africa. Fennel is a plant of warm regions in the temperate zone, typified by the Mediterranean climate. Fennel spread to other regions, including colder locations, through the selection and conversion. In Central Europe, fennel was introduced in medieval times (in South Moravia, south Slovakia, and Hungary) (Slavík, 1997). The largest areas of cultivation occurred between 1925 and 1938. After the 2nd World war, the area of cultivation decreased. In the 1970, south Moravian fennel was very famous and fetched a good price on the market (Růžičková, 2005).

6: *Fennel achenes*
Source: Růžičková, G.

Botany

Fennel is a biennial to perennial plant with an erect stem, 500–2000 mm in height, rounded, slightly longitudinally striped, and branched. The leaves have cased petioles, 30 –60 mm long, which are oblong, triangulate, and 3–4 × pinnatisect. The narrow, long, lined to thread-like segments 5–50 mm long are strongly aromatic. Inflorescences are umbells; they are flat, 150 mm in diameter, and contain 4–30 umbellates (Fig. 7). Individual flowers are bisexual, small, and yellow, without covers. The calyx is missing. Fennel flowers from July to September. The fruits are double achenes, oblong, ovate, with 5 ribs, 8 mm in length. The fruit's aroma is strong; the taste is spicy and slightly sweet (Slavík, 1997).

7: *Fennel umbels*
Source: Růžičková, G.

Agroecology

Fennel is cultivated as an annual to perennial plant in temperate zones. The optimal day temperature is 15–20 °C and optimal precipitation is around 400–750 mm during the vegetative period. It germinates at +6 to +8 °C. In the flowering period, it needs day temperatures above 20 °C. It is possible to cultivate fennel in many types of soil, from heavy clays to light sandy soils, from stony hills to river floodplains. Fennel tolerates mild alkaline soils (pH 6.5–8.0) but does not tolerate salinity. In the conditions of Central Europe, fennel needs deep loamy soils with a high content of calcium and other nutrients, and with good water balance (Růžičková, 2005).

Technology of Cultivation

European varieties used for the production of seeds are cultivated as biennials to perennials, maximally for four years of cultivation. Fennel is not in demand as a fore crop. Alfalfa, sunflower and all *Umbelliferae* plants are not suitable. The best fore crops are root crops fertilized with animal fertilizers, as well as cereals. Recommended regions for fennel in Central Europe are the warmest regions (maize production regions). Seeds are sown in March–April, in rows of 0.45–0.60 m, the sowing rate is 10 $kg.ha^{-1}$, with seed depth of 20–30 mm.

The seeds germinate and emerge in 14–30 days, depending on soil moisture. Fennel flowers from July to September. One year old plants die after the first long-term frosts. The following year it starts to grow early in the spring, formats the stem in the beginning of May, flowers at the end of June, and its fruits mature in September. Fennel stays on the plot for 2–3 years. Fennel requires a good level of mineral fertilizing, mainly phosphorus. It is possible to fertilize it with P and K in doses of 46–65 kg $P.ha^{-1}$ and 50–83 kg $K.ha^{-1}$. In spring, fennel can be fertilized with an additional dose of nitrogen: 40–60 kg $N.ha^{-1}$. When the stem is forming, the ammonium form of nitrogen can be added (20–30 kg $N.ha^{-1}$). In the second year, the dose of nitrogen shall be around 60–80 $kg.ha^{-1}$. Registered pesticides can be used for the regulation of weed infestation, pathogens and insect attacks (Růžičková, 2005).

Harvest and Postharvest Treatment

The fruits mature heterogeneously; the achenes break down. The harvest has to be started when the umbels of the first order are mature, they have a grayish green color, and 2/3 of umbels are mature. Freshly harvested seeds have to be cleaned and dried at a max. temperature of 35 °C, with moisture approximately at 10%. The yield ranges from 0.4–0.9 $t.ha^{-1}$ in the first year, 0.6–1.3 $t.ha^{-1}$ in the second year and 0.2–0.9 $t.ha^{-1}$ in the third year (Růžičková, 2005).

Active Substances and Quality

The fruits contain the essential oil (1–6%) with the following main compounds: trans-anethol (50%), fenchone (10–20%), limonene (30–10%), α-phellandrene (3–11%), α-pinene (12–16%), α-thujene, β-pinene, methylchavicol, myrcene, and 1,8-cineole (Růžičková, 2005).

In Central Europe, the content of the essential oil in fennel varies from 0.7–2.5% and in flowering fennel from 1–3.7%.

Use and Properties

Fennel is used in the preparation of bread, pastry, soups, salads, minced meat, and fish. It is also used in the production of the liqueurs, herbal teas, confectionery, food supplements, perfumes, and herbal soaps. The seeds play a role in veterinary medicine. Fennel canopies are important for bees. Fennel has carminative, antimicrobial and antioxidant properties. It is used traditionally as a digestive, in case of stomach problems, and is widely used in pediatrics and folk medicine (Růžičková & Kocourková, 2012).

Milk thistle (Silybum marianum [L.] Gaertn.)

Milk thistle is an annual or biennial plant, native to the Canary Islands. It grows as a wild plant in southern Europe, western Asia and northern Africa (Hassan El-Mallah *et al.*, 2007). Milk thistle is produced for the content of the silymarin complex in its fruits (achenes) (Habán, 2009; Abenavoli *et al.*, 2010). The fruits also contain an important amount of fatty oil (Moudrý, 2011).

Botany

Milk thistle belongs to the *Asteraceae* family. The stem is 0.30–2.50 m in height. Plants have a taproot; the stem is branched in the top part. The leaves are alternate; ground leaves form the rosette. The leaves have typical white spots and thorny edges. The inflorescences – anthodia are individual, erect, and with long stems, 3–7 cm in width (Fig. 8). The flowers are tubular, white to light violet (Slavík & Štěpánková, 2004). The parts of the plant that are used are the fruits (achenes) without the silver pappus. The achenes are 5–7 mm long, 2–3 mm in width, and 1.5 mm thick. The fruit surface is shiny; the color is brownish black to greyish brown. Freshly-ground achenes have a cocoa flavour and a fatty, bitter taste (Habán *et al.* 2009). Milk thistle flowers from July to September (Slavík & Štěpánková, 2004).

8: *Detail of milk thistle anthodium*
Source: Růžičková, G.

Cultivation

Milk thistle is grown commercially mainly in Germany, China, Argentina, Romania, and Mediterranean countries (Abenavoli *et al.*, 2010). Recently, the area of milk thistle cultivation increased in Bulgaria, Poland and Czech Republic (Andrzejewska *et al.*, 2011; Koláčková *et al.*, 2014). While in some states of North- and Central America, Africa, Australasia and in the Middle and Near East, milk thistle is considered a problematic invasive weed (Fig. 9) (Holm *et al.*, 1997).

9: *Field with milk thistle*
Source: Růžičková, G.

Milk thistle grows successfully on a range of soil types, from sandy soils to much heavier clay soils (Karkanis *et al.* 2011). An environment with rich soil humus, with neutral soil alkalinity and with a sufficient amount of moisture, is optimal. Shallow, gravel, sandy soils with high acidity, as well as dry southern slopes without enough water are not suitable (Moudrý, 2011). Leguminous plants, organically fertilized crops and cereals are appropriate fore crops. The sowing rate ranges 5–8 kg.ha^{-1}, but other authors recommend higher rates, of up to 12–24 kg.ha^{-1} (Andrzejewska *et al.*, 2011). The moment of sowing depends on the weather and can be performed from March to April, when the soil temperature reaches min. 5 °C. The depth of swing should be 2–3 cm (Spitzová, 1985), the plant density is recommended between 0.30 × 0.30 m to 0.40 × 0.40 m. The number of plants per 1 m^2 should range from 6–12. The methodology of the Agriculture Research Institute in Kroměříž recommends the application of 45–60 kg N, 17.5 kg P and 33.2 kg K per hectare. Andrzejewska and Skinder (2006) found that the yields of milk thistle grown in monoculture were about 40% lower than the yields obtained in crop rotation. Furthermore, yields recorded in the agro ecological conditions of South Slovakia were from 0.5 to 1.7 t.ha^{-1} (Gromová, 1997; Habán, 2004), 0.55–1.68 t.ha^{-1} in Poland (Andrzejewska *et al.*, 2011) and 0.5–1.2 t.ha^{-1} in Czech Republic (Koláčková *et al.*, 2014). Andrzejewska and Sadowska (2007) found that the content of silymarin is mostly correlated with weather conditions during the vegetation period and also with the time of sowing (Andrzejewska *et al.*, 2011).

In higher localities and in rainy weather, the anthodia are attacked by fungi *Alternaria* and *Botrytis* during the period when they form achenes. These fungi cause necrosis of the top parts of the plants; the achenes are turn pinkish, do not mature or suffer from white mould (Fig. 10). The yield decreases (Spitzová, 1985).

10: *Milk thistle achenes*

Source: Koláčková, P.

Severalvarieties of milk thistle have been developed. The silymarin content most often ranges from 1.0% to 3.0% of achene dry matter but can exceed 8%. Efforts should be made to develop varieties with high-silymarin content (Karkanis *et al.*, 2011). Polish, Slovakian and Czech results show the average content of silymarin in the achenes to be 1.55–2.4% (Andrzejewska *et al.*, 2011; Habán *et al.*, 2009; Koláčková *et al.*, 2013).

Active Substances

The seeds of milk thistle contain silymarin (Karkanis *et al.*, 2011), and a mixture of numerous flavonolignans – silibinin A and B, isosilybin, silychrystin and silydianin (Sanchez-Sampedro *et al.*, 2005). The seeds also contain oil in amounts of 20–30% (w/w) (Růžičková *et al.* 2011; Ahmand *et al.*, 2007). The oil of Milk thistle achenes of various origins mainly contains linoleic acid (51–66%), as well as oleic acid (16–25%) (Růžičková *et al.*, 2011; Koláčková *et al.*, 2013).

Use and Properties

The seeds contain the highest amount of silymarin, but the whole plant is used medicinally. Young fleshy stems are traditionally eaten by Arabs living in Israel, and its sprouts, which are rich in antioxidants, have been used as a traditional medicine for diseases of the liver and biliary tract (Vaknin *et al.*, 2008). This active substance positively affects liver tissue; helps treat diseases of the gall bladder, including hepatitis and cirrhosis. It protects the liver against intoxication by mushroom toxins and alcohol, as well as snake poison and pest bites (Habán 2009; Abenavoli *et al.*, 2010). Milk thistle has an antioxidant effect;

it supports gallbladder function, eases digestive problems, and helps against depression and fatigue (Racz *et al.*, 1990; Pares *et al.*, 1998; Bruneton, 1999). Fatty oil is a side-product used for cosmetic production and animal feeding. In addition, it has also been tested as an alternative source for fuel production. According to recent studies, its oil can be used for the production of biodiesel (Fadhil *et al.*, 2012).

Summary

Central European countries are a traditional production region for medicinal plants cultivated on large areas or collected from wild natural habitats. The quality of the medicinal properties of the plants mainly depends on the content of secondary metabolites, which are influenced by the interaction of many factors, including environmental factors, agrotechnology, and genetic background (variety). Agronomists are interested in the highest yields and prices for their products. Today, under European medical legislation, medicinal products containing herbal substances/preparations must fall within one of the following three categories to reach the market: a product for "traditional use" (this has a simplified registration procedure), a product for "well-established use", and a product authorised after official evaluation.

To use medicinal plants and products derived from them in the therapy of many diseases is trendy, and phytotherapy has recently experienced a renaissance. On one hand, consumers and patients want high quality products with a standardized amount of active substances, produced under strict conditions; on the other hand, the ecological and technological requirements of individual species of medicinal plants have to be respected. The production of medicinal plants can be successful only when the relevant purchasing price is guaranteed, and farmers or collectors benefit from this activity. It is widely known that prices paid to farmers for their production has not change in the past twenty years in most Central European countries, but prices of other products have greatly increased. The processors have other problems, e.g. many legislation problems and strict conditions regarding safety, critical and control points, GACP, and traceability. They are dependent on their own buying stocks, or else they have to buy raw material worldwide from the other processors. Raw material from Central Europe is purchased by 3–5 main buyers in Germany, Poland and Hungary. These companies sell the product to processors in all European countries. There is another issue to discuss – the profession, "collector of plants", is not officially recognized in many countries. Together with low prices, lack of interest, and higher age of local inhabitants, the number of collectors decreased dramatically in the last 5 years, for example in South Europe. Typical collectors are vulnerable groups of people – elderly women with basic or middle education, women on maternity, seniors, as well as people who live in the country and who have low income. Recent studies confirm deep knowledge about plants, their cultivation, collection and use in some regions of Central Europe. Also, in some localities, traditional knowledge and habits are passed down from generation to generation, but in some regions, traditions related to plants and their uses have been lost.

The principles of sustainable collection of wild plant are paramount in regions where local plant populations are endangered by large-scale collection, e.g. in Southern European countries. Some studies in Poland, Hungary, Czech Republic and Slovenia do not confirm such a threat to the main collecting species (*Sambucus nigra, Rosa canina, Urtica dioica, Lamium album, Equisetum arvense, Thymus serpyllum, Matricaria recutita*).

The cultivation and collection of medicinal plants should be a part of the agricultural and cultural heritage and activities of local populations with relevant inputs and incomes for farmers, collectors and producers.

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