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COMMERCIALLY IMPORTANT PROPERTIES OF PLANTS OF THE GENUS *Plantago*

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Abstract

The centuries-old experience of folk medicine, nutritional traditions, and the results of numerous research studies show that plants of the genus *Plantago* can be used for medicinal, cosmetic, dietetic, and ritual purposes.

In the phytochemical composition of *Plantago*, there is an abundance of biologically active substances (among others, glycosides, flavonoids, polysaccharides, and vitamins) exhibiting beneficial effects and, simultaneously, there is a low content of compounds that may exert a toxic effect. Scientific research has confirmed that *Plantago* plants have antioxidative, apoptosis-inhibiting, protective, healing-enhancing, spasmolytic, anthelmintic, and antimicrobial properties; they inhibit the development of some tumours, reduce the level of lipids in blood and inhibit tissue glycation. In phytotherapy, leaves, stems, and/or seeds of different plantain species are used.

Plantago leaves and seeds are also used to manufacture creams, lotions, and face masks. Different parts of these plants (fresh plant material, extracts, or isolated substances) are also used in human and animal nutrition. Plantain leaves can be eaten like lettuce or added to salads, fried in pastry, used to prepare a tea, juice, or wine. Its seeds are added to cakes, bread, breakfast cereals, ice cream, and drinks, or they are cooked like groats. Animals fed with plantain can live longer and are healthier, while meat derived from such animals is tastier and healthier to humans. *Plantago* seeds are readily eaten by cage birds.

Plantain pollen, produced in large amounts (up to 20,000 pollen grains per 1 stamen of *P. lancolata*), can cause allergies in sensitive people. Due to a long flowering period of plants of the genus *Plantago*, the effect of the allergenic factor persists for many weeks. In Poland days with the maximum concentration of airborne plantain pollen most often occur in July.

Key words: *Plantago*, medicinal uses, cosmetics, edible plants, animal feed, allergenic pollen.

THE HISTORY OF USE OF *Plantago* PLANTS

Various *Plantago* species have been used as food for humans and animals as well as medicinal, cosmetic, and ritual plants. The traditional and multiple uses of these plants are confirmed by ethnobotanical and ethnopharmacological research (Samuelsen, 2000; Łuczaj, 2004; Cornara et al. 2009).

The medicinal properties of *Plantago lanceolata* have been known since ancient times. This species was used in China already 3000 years ago. In ancient Rome Pliny the Elder recommended plantain as a medicine for 24 diseases. In folk medicine of many countries, the aerial parts of *P. lanceolata* are used externally and internally to treat different ailments (Nowiński, 1983; Nishibe, 2002). In Italy the resin of *P. lanceolata* was used as a substitute for incense smoke in church rituals. Inflorescences of this plantain, mixed with stems of other plants (*Helichrysum*, *Thymus*), were burnt to perfume clothes and rooms with the smell of smoke (Cornara et al. 2009).

Plantago major was included among the most important herbs in the Chinese herbarium dated from the 1st century A.D. It was also used in ancient Greece and Rome. Dioscorides, Pliny the Elder, and Galen recommended it against snake and scorpion bites. It was also used in therapy during the Middle Ages (Nowiński, 1983; Samuelsen, 2000; Strzelecka and Kowalski, 2000). Seeds of *P. major* were placed in the tombs of pharaohs, while its leaves were used as a vegetable by the Chinese. Plantain was called White Man's Foot by North American Indians, since it grew everywhere where the white man appeared. The Shoshone Indians applied heated leaves of this species to wounds (Clark, 1977).

THE CHARACTERISTICS OF THE GENUS *Plantago*

The family Plantaginaceae comprises about 265 species widespread in temperate climate areas. The genus *Plantago* includes about 260 species of perennials, annuals and, exceptionally, shrubs (Szweykowscy, 2003). In Poland 17 species of the genus *Plantago* are found growing in the wild, among others, *P. lanceolata* L., *P. major* L., *P. media* L., *P. arenaria* Waldst. and Kit., *P. maritima* L., *P. altissima* L., *P. patagonica* Jacq., *P. intermedia* Gilib., *P. coronopus* L., *P. atrata* Hoppe, *P. serpentina* All., and *P. winteri* Wintg. (Mirek et al. 2002). The first four above-mentioned taxa belong to medicinal plants. Moreover, other plantain species are included among plants used in therapy, *inter alia*, the ones growing in the Mediterranean area: *P. afra* L. (= *P. psyllium*), *P. ovata* Forsk., *P. asiatica* L., and *P. depressa* Willd. (Andrzejewska-Golec, 1994). These plants can reproduce from seed or vegetatively from buds formed on their roots (Maurizio and Grafl, 1969).

The leaves of plants of the genus *Plantago* form a ground rosette. The leaf blades are entire or denticulate. The flowers are small, bisexual, most frequently borne in spike-like inflorescences (Fig. 1A). They produce a delicate scent in some species. The perianth consists of a 3-sepalled calyx and a 4-petalled corolla forming a tube and 4 membranous lobes (Reardon et al. 2009). The androecium comprises 4 stamens fused to the corolla tube which are several times longer than the petals (Fig. 1A). In these flowers, the stamens perform the role of the attractant. In *P. media*, they are lily coloured and attract numerous insects (Lipiński, 2010). The stamens have a rare feature of closing their anthers at high air humidity, which protects pollen against water (Maurizio and Grafl, 1969). *Plantago* flowers represent an intermediate degree between anemophily and entomophily; for instance, under favourable weather conditions bees perform the pollination while collecting the pollen of *P. lanceolata*, whereas in adverse weather its flowers are pollinated by the wind. These flowers do not produce nectar (Kugler, 1970).

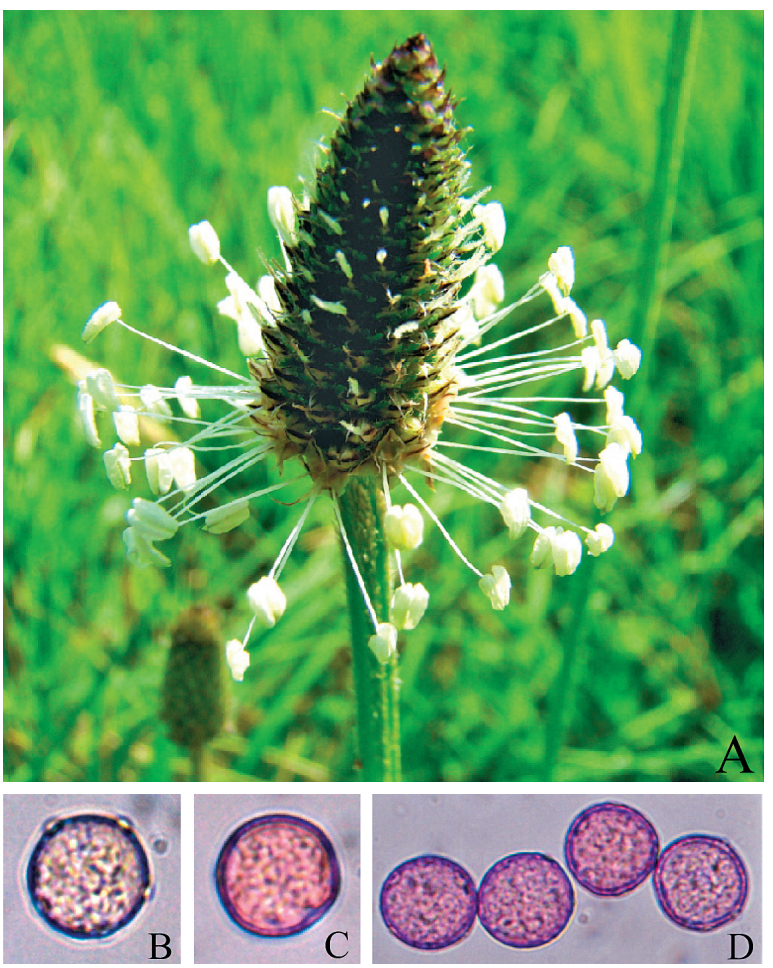

Fig. 1. Inflorescence of *Plantago lanceolata* (×3). B-D. Pollen grains of *P. media* (B) (×670), *P. major* (C) (×700), *P. lanceolata* (D) (×530).

A capsule (fruit), which opens by a lid, develops from the pistil of the superior, mostly bilocular ovary (Podhajská and Rivola, 1992; Szweykowscy, 2003). The existing research shows that fruits originating from different populations of *Plantago lanceolata* significantly differ in size and shape (Truchan, 2005). The fruit of *Plantago* has a special feature, since it dehisces and releases seeds when it is wet (hygrochasy) and closes when dry (Weberling, 1992). In the fruit, there are usually 2 seeds and their coat can have different shades of brown. The seeds are elliptically-shaped and their surface is smooth and shiny. In the seed coat, there are cells accumulating mucilage and, as a result of that, soaked seeds swell up quickly and stick to the medium (Maurizio and Grafl, 1969; Podhajská and Rivola, 1992; Świdzińska, 1998).

Tab. 1.
Characteristics of some species of *Plantago* and their traditional medicinal uses

No.	Species	Occurrence	Morphological features	Traditional medicinal use	References
1.	*Plantago lanceolata* L.	Europe, north Asia, Middle Asia.	Plant height 10-60 cm. Lanceolate leaves form a ground rosette; brown flowers borne in spikes 1-3 cm long.	Herbal infusion – compresses for wounds, burns; leaf juice used for ulcers and eye diseases.	Strzelecka and Kowalski, 2000; Podbielkowski and Sudnik-Wójcikowska, 2003.
2.	*Plantago major* L.	Europe, Asia.	Plant height up to 40 cm. Ovate, entire leaves form a ground rosette. Small greenish flowers borne in a long, cylindrical spike.	Compresses from fresh leaves for wounds and ulcers; irrigation of wounds with leaf infusion; an antitussive agent.	Strzelecka and Kowalski, 2000; Podbielkowski and Sudnik-Wójcikowska, 2003.
3.	*Plantago media* L.	Europe.	Plant height 10-50 cm. Elliptical leaves borne in a rosette. Fragrant flowers with a whitish corolla form short spikes.	Anti-inflammatory, astringent, expectorant activity.	Anioł-Kwiatkowska et al., 1993; Podbielkowski and Sudnik-Wójcikowska, 2003.
4.	*Plantago arenaria* Waldst. and Kit. (= *P. indica*)	Europe, west Asia, west Africa.	Plant height up to 40 cm. Its linear leaves are arranged oppositely. Whitish flowers form globular spikes growing from the axils of the highest leaves.	Mild purgative.	Strzelecka and Kowalski, 2000; Podbielkowski and Sudnik-Wójcikowska, 2003.
5.	*Plantago psyllium* L. (= *P. afra*)	South Europe.	Plant height ca. 30 cm. Linear, opposite leaves, stems branched. Flowers with a brown corolla grow from the leaf axils.	Purgative.	Strzelecka and Kowalski, 2000; Podbielkowski and Sudnik-Wójcikowska, 2003.
6.	*Plantago ovata* Forsk.	South Europe, south-west Asia, South America, North America.	Plant height 20-40 cm. Linear, woolly haired leaves form one or several ground rosettes. The inflorescence is a spike.	Mild purgative.	Senderski, 2007; Podbielkowski and Sudnik-Wójcikowska, 2003.
7.	*Plantago asiatica* L.	Japan, Korea, China, Indochina, Malaysia, Taiwan, east Siberia.	Plant height 30-50 cm. Entire leaves with a parallel venation forming a ground rosette. Small flowers borne in a spike-like inflorescence.	The herb is a detoxicating, purgative, antipyretic agent; it improves eyesight; compress for wounds. Seeds – used in stomach ulcer disease and rhinoconjunctivitis; compress for snakebites.	Andrzejewska – Golec and Makowczyńska, 2005.
8.	*Plantago depressa* Willd.	Asia – from the Ural Mountains to China and Japan.	Plant height >10 cm. Elliptical leaves, elliptical – lanceolate to oval, erect; they grow from a short stem. Small, white flowers.	Purgative.	Kletter snd Kriechbaum, 2001; www.eFloras.org

Leaf anatomical characters

The leaves of *P. lanceolata* show the isolateral structure. Diacytic stomata are distributed in the upper and lower epidermis. The mesophyll consists of 1-3 layers of palisade parenchyma, located on both sides of the epidermis, and a multi-layered spongy parenchyma situated in the central part of the lamella (Kohlmünzer, 1998; Gostin, 2009). In other plantain species, e.g. *P. lessingii*, the spongy parenchyma is poorly developed (Yukun, 1994). The largest spongy parenchyma cells in the leaves of *P. lanceolata* are found in the inner layers of the mesophyll, and their diameter decreases in the direction of the epidermis (Gostin, 2009). Vascular bundles and mucilage-accumulating cells are distributed in the mesophyll (Maurizio and Grafl, 1969).

Contrary to the previously mentioned species, the leaves of *P. major* have a structure typical for leaves of dicotyledons. They are characterized by 3 layers of palisade parenchyma on the side of the upper epidermis and several layers of spongy parenchyma on the side of the lower epidermis (Onoda et al. 2008).

Glandular and non-glandular hairs occur on the leaf surface in representatives of the genus *Plantago*. The glandular trichomes can be club-shaped and they have a unicellular head or the head is divided vertically into two cells. The non-glandular trichomes located on the leaves of *Plantago* have different shapes and structures. They can be very short, 1-3-celled, slightly longer, consisting of 2-9 cells, or multicellular, composed of 14-40 cells. These hairs are characterized by a smooth or papillose cuticle (Andrzejewska-Golec and Świętosławski, 1993, 1998; Andrzejewska-Golec, 2000, 2003).

ALLERGENIC PROPERTIES OF *Plantago* POLLEN

Likewise in many anemophilous plants, all *Plantago* species produce large amounts of pollen. It has been calculated that one stamen of *P. lanceolata* releases 7 700 – 20 000 pollen grains, in *P. media* it is 6 000 – 14 000 pollen grains, while in *P. major* 5 870 grains. One inflorescence of these species produces, respectively, 2 million, 3.3 million, and 6.3 million pollen grains (Kugler, 1970; Świdzińska, 1998; Piotrowska, 2008). The research also shows that one flower of *Plantago* produces on average 1 mg of pollen (Maurizio and Grafl, 1969).

Pollen grains of *Plantago* are spherical and multiporate with small verrucae on the exine surface (Beug, 2004) (Figs. 1B-D). Their diameter is in the range of 16-35 µm (Watson and Constable, 1991), while according to Beug (2004) this value is the following for the respective species: *Plantago lanceolata* 22.3-27.8 µm, *Plantago major* 19.5-27.0 µm, *Plantago media* 27.0-32.0 µm. The pore diameter in pollen grains of the above-mentioned species ranges from 2.0 to 6.0 µm. Pollen grains of *P. major* have a small number of pores (5-8), whereas this number is much higher for *P. media* (7-11) and *P. lanceolata* (9-15) (Beug, 2004).

Species of the genus *Plantago* are included in the list of plants producing allergenic pollen (Baldo et al. 1982; D'Amato et al. 1991). Symptoms of allergy induced by the effects of *P. lanceolata* pollen have been recorded in North America, Europe, and Australia. Since the flowering period of all representatives of this family lasts several months and plants produce significant amounts of pollen, the risk of pollen allergy in sensitive people can continue for many weeks (Watson and Constable, 1991).

First pollen grains of *Plantago* are recorded in the air in particular regions of Poland at different times. They have been recorded earliest, already in the third decade of April, in Poznań and Łódź (Majkowska-Wojciechowska et al. 2006; Stach, 2006), and latest (the second decade of May) in Szczecin and Lublin (Puc, 2006; Weryszko-Chmielewska and Piotrowska, 2006). Maximum concentrations of *Plantago* pollen grains in aeroplankton of different regions of Poland during the period 2001-2005 ranged 3-33 pollen grains per 1 m^3 of air; these values were the highest in Sosnowiec, Rzeszów and Lublin, and the lowest in Poznań, Wrocław, and Łódź. Days with the maximum concentration were most frequently noted in different decades of July, less frequently in June or August (Weryszko-Chmielewska, 2006).

P. lanceolata has the greatest allergenic importance. The most often described allergen is designated *Pla l* 1 and it has a weight of 16-20 kDa. It shows cross reactions with the olive allergen *Ole e* 1 (Calabozo et al. 2001).

MEDICINAL USES

Numerous species of the genus *Plantago* owe their properties to the presence of many biologically active substances, *inter alia*, glycosides, flavonoids, polysaccharides, and vitamins.

Plantago lanceolata

The leaf of ribwort plantain (*Plantaginis lanceolatae folium*) is raw material recognised in Polish Pharmacopoeia VI and European Pharmacopoeia 5. Raw material products are recommended for internal use in airway infections as well as mucosal inflammatory changes of the oral cavity and throat; externally, it is used in dermatitis. Biologically active substances found in ribwort plantain include, among others, iridoid glycosides, flavonoids, polysaccharides in the form

of water soluble mucilages, and tannins (Kohlmünzer, 1998).

The level of iridoid glycosides, which include aucubin and catalpol, in a natural population of *P. lanceolata* can reach even 9% of dry weight. Aucubin is a precursor in catalpol biosynthesis (Bowers, 1991). Other studies show that the level of aucubin and catalpol in the leaves of seven *Plantago* species was up to, respectively, 0.27% and 1.81% of leaf dry weight (Jurišić et al. 2004).

Aucubin exhibits numerous pharmacological activities: antibacterial, anti-inflammatory, and it also facilitates healing of skin wounds. It can be useful in local treatment of oral wounds (Shim et al. 2007). Aucubin is a specific inhibitor of NF-kB in mast cells, which may have a beneficial effect in the treatment of chronic allergic conditions (Jeong et al. 2002). This glycoside has been shown to have an antiproliferative effect on cancer cells (small-cell lung carcinoma), inducing their apoptosis (Hung et al. 2008).

Ground leaves or juice from fresh leaves of *P. lanceolata* are used to control external animal skin parasites. Both ethanol and aqueous extracts from leaves of this plant species have shown antihelminthic activity in mice (Kozan et al. 2006).

Ribwort plantain is also used in the treatment of burns, insect bites, and stomach ulcers (Strzelecka and Kowalski, 2000; Sarwa, 2001). Leaf extracts have expectorant and antitussive effects as well as they exhibit immunotropic, adaptogenic, and diuretic activity (Andrzejewska-Golec, 1994). They are also used for eye irrigation in rhinoconjunctivitis (Samuelsen, 2000; Sarwa, 2001).

Plantago major

Medicinal raw material is the leaf of common plantain (*Plantaginis maioris folium*) which contains iridoid glycosides, flavonoids, mucilaginous compounds, phenolic acids, tannins, triterpene compounds, vitamins C and K as well as mineral compounds (Kohlmünzer, 1998; Strzelecka and Kowalski, 2000).

Leaf extracts exhibit protective and anti-inflammatory effects in digestive tract diseases, bronchitis, and pharyngitis (Strzelecka and Kowalski, 2000).

Plantago major is a popular plant that has been used by Chinese medicine for many years to treat viral diseases, from common colds to viral hepatitis. Phenolic compounds (caffeic acid) isolated from the leaf extract of this plantain show strong antiviral activity, in particular against HIV-1 as well as HIV-2 and ADV-3 at multiplication stages (Chiang et al. 2002).

P. major has properties stimulating the immune system. At specific doses, it causes proliferation of lymphocyte cultures. Seeds of this taxon show antidiarrhoeal activity (Lans et al. 2007). One of flavonoids found in plantain is baicalein which causes the death of cancer cells and inhibits the growth of human hepatoma cell lines (Motoo and Sawabu, 1994) as well as exhibits strong antiproliferative effects on rat liver cancer cultures (Inoue and Jackson, 1999). Numerous studies have shown that extracts of *P. major* have cytotoxic effects on cultures of different human cancer cell lines and human leukaemic cells (Matsukawa et al. 1993; Le Bail et al. 1998; Gálvez et al. 2005). Samuelsen (2000) reports about the antitumor use of *P. major* by folk medicine in the Canary Islands, Venezuela, Chile and Panama.

In the case of three other species: *Plantago psyllium*, *P. arenaria*, and *P. ovata*, medicinal raw material is the seed called *Plantaginis semen.* The seed coat contains mucilage and hemicellulose which cause a strong swelling of seeds. Mucilaginous compounds found in medicinal raw material contain xylose, rhamnose, arabinose, galactose, and uronic acids as well as sugars (planteose, glucose, and fructose), oil, phytosterols, aucubin, monoterpene, and triterpene alkaloids. Seeds of the aforementioned species are used as a protective and coating drug and also as a purgative. *P. arenaria* and *P. ovata* seeds have also been found to reduce the level of cholesterol (Strzelecka and Kowalski, 2000; Senderski, 2007). Seed husks of *P. ovata* and *P. psyllium* are currently used in the pharmaceutical industry (Chan and Wypyszyk, 1988; Dhar et al. 2000; 2005).

Rozaeipoor et al. (2000) showed that an extract of *P. ovata* seeds significantly affected the immune system of rabbits. It caused a reduction in anti-HD antibodies as well as an increase in the number of white blood cells and spleen leukocytes. The aqueous extract of *P. ovata* seeds reduced hyperglycaemia in type 1 and 2 diabetes in rats. These properties show that this extract can be used in diabetes treatment (Kordošová and Machová, 2006).

Treatment with *P. ovata* seed coat preparations increases and stabilises the level of HDL – cholesterol, thereby reducing the risk factors of cardiovascular system diseases (Solà et al. 2007).

APPLICATION IN COSMETICS

Plantago lanceolata and *P. major* are included in the list of cosmetic plants. Aqueous infusions and stabilised fresh juice from leaves of these both plantain species are used in cosmetics. Antiseptic, antibacterial, and astringent effects of their leaves are utilised (Podbielkowski and Sudnik-Wójcikowska, 2003; Czerpak and Jabłońska-Trypuć, 2008). The extract from the leaves of *P. lanceolata* is used to produce different cosmetics, among others, creams, lotions as well as face masks for oily and acne

skin (Podbielkowski, 1992; Jędrzejko et al. 2007).

Other authors (Hlava et al. 1984) recommend the use of crushed fresh leaves of *P. lanceolata* in face masks. These researchers also mention the species of *P. psyllium* whose seeds contain up to 10% of mucilage and are used to prepare a macerate in cold water and subsequently to produce nourishing creams and lotions. The literature confirms that seed husks of *P. ovata* and *P. psyllium* have found application in the cosmetics industry (Dhar et al. 2005).

Plantago AS AN EDIBLE PLANT

Plantago major was used as a vegetable in China and by North American Indians, for example, from the Cherokee and Mohican tribes (Łuczaj, 2004).

Leaves of different *Plantago* species are eaten raw or cooked, and their taste is compared to that of chard. Only young leaves are consumed in the form of salads, since older ones are fibrous and bitter (Clark, 1977; Łuczaj, 2004). In Italy *Plantago lanceolata* leaves are used as an addition to salads or are eaten like lettuce (Samuelsen, 2000; Heimler et al. 2007).

Plantain leaves are also used as an addition to soups and as a cooked vegetable. In the past, people used to eat them especially during the spring period when vegetables were in short supply (Samuelsen, 2000). The leaves of *P. maritima* are tasty and they are added to chicken soup in France, whereas the leaves of *P. coronopus* are used in salads in Italy and France. Leaves of different plantain species can be fried in pastry (Łuczaj, 2004), while *P. lanceolata* leaves can be used to prepare an infusion, tea, tincture, wine, juice, and macerate (Clark, 1977).

Plantago seeds can be cooked as groats or, after grinding, they are added to cakes and bread (Łuczaj, 2004; Dhar et al. 2005). They are also included in breakfast cereals, ice cream, or instant beverages (Dhar et al. 2000, 2005). Aqueous extracts of *P. ovata* seed husks are recommended in diets for diabetics, since they have been found to reduce hyperglycaemia in type 1 and 2 diabetes (Hannan et al. 2006).

PLANTAIN LEAVES AS ANIMAL FEED

Herbs are used more and more widely as animal feed ingredients. They are used individually or in the form of herbal mixtures added to nutritious feeds for all animal species (Fritz and Grela, 1995).

The positive effects of herbs on animal organism consist in improving the taste and smell of animal fodder, regulating digestive functions, increasing resistance to infections, and contributing to the characteristics of meat and fat desired by the consumer (Grela, 1995).

Plantago lanceolata is a plant that is officially allowed in animal nutrition (Grela, 1997). It was demonstrated that the addition of herbal mixture containing *P. lanceolata* in the feeding of porkers improved meat taste and increased the amount of unsaturated acids, which is a desired feature in human nutrition (Grela and Baranowska, 1999). *P. lanceolata* stems are recommended as a food integrator for rabbits and other animals (Cornara et al. 2009). On the other hand, seeds dried, roasted, or milled for flour are used as food for cage birds. Seeds of this plantain are a delicacy for canaries (Clark, 1977; Fijałkowski and Chojnacka-Fijałkowska, 2009).

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Właściwości użytkowe roślin z rodzaju *Plantago*

Streszczenie

Wielowiekowe doświadczenia medycyny ludowej, tradycje żywieniowe oraz wyniki licznych badań naukowych wskazują, że rośliny z rodzaju *Plantago* mogą być wykorzystywane w celach leczniczych, kosmetycznych, dietetycznych oraz rytualnych.

W składzie fitochemicznym *Plantago* występuje bogactwo substancji biologicznie czynnych (m. in., glikozydy, flawonoidy, polisacharydy i witaminy) o korzystnym działaniu, przy jednoczesnej niewielkiej zawartości związków o właściwościach toksycznych. Badania naukowe potwierdziły, że rośliny te mają właściwości antyoksydacyjne, hamujące apoptozę, osłaniające, przyspieszające procesy gojenia, spazmolityczne, przeciwrobacze, przeciwdrobnoustrojowe, hamujące rozwój niektórych nowotworów, a także obniżające poziom lipidów we krwi oraz hamujące procesy glikacji w tkankach. W fitoterapii stosuje się liście, pędy lub/i nasiona różnych gatunków babki.

Liście i nasiona *Plantago* znajdują także zastosowanie do wyrobu kremów, lotionów i maseczek. Różne części tych roślin (świeży surowiec, ekstrakty lub wyizolowane substancje) wykorzystywane są również w żywieniu ludzi i zwierząt. Liście babki można spożywać jak sałatę, smażyć w cieście, przyrządzać z nich herbatę, sok czy wino. Nasiona dodawane są do ciastek, chleba, płatków śniadaniowych, lodów, napojów lub gotowane są jak kasza. Zwierzęta karmione babką mogą żyć dłużej i są zdrowsze, zaś mięso z nich pochodzące jest smaczniejsze i zdrowsze dla ludzi. Nasiona *Plantago* są chętnie zjadane przez ptaki utrzymywane w klatach.

Natomiast pyłek babki ma właściwości alergizujące. Produkowany w dużych ilościach (do 20 tys. ziaren pyłku/1 pręcik *P. lancolata*) może wywoływać alergie u osób wrażliwych. Z uwagi na długi okres kwitnienia roślin z rodzaju *Plantago*, działanie czynnika alergizującego utrzymuje się przez wiele tygodni. W Polsce dni z maksymalną koncentracją ziaren pyłku babki w powietrzu najczęściej występują w lipcu.