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BIOLOGICAL VALUE OF VARIOUS EDIBLE FLOWER SPECIES

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Abstract. Flowers are an important part of a plant which contains a great variety of natural antioxidants, such as polyphenols, carotenoids and many other bioactive and nutraceutical compounds. Edible flowers have been used in culinary preparations for centuries to improve the nutritional and sensorial qualities of food. The aim of the experiment was to compare the biological value of *Borago officinalis, Lavandula angustifolia, Oenothera biennis*, *Viola tricolor*, *Bellis perennis*, *Salvia splendens*, *Tagetes tenuifolia*, *Verbena × hybrid, Begonia semperflorens* and *Begonia × tuberhybrida* flowers. Among the compared edible flower species, signet marigold showed the highest biological value due to the highest amounts of L-ascorbic acid, total carotenoid and total polyphenol content and the highest antioxidant activity. Moreover, the flowers of heartsease were characterized by the highest content of total ash, saccharose, and chlorophylls; lavender flowers – by the highest content of dry matter, crude fibre, total soluble and reducing sugars; scarlet sage flowers – by the highest content of total nitrogen and total protein; while wax begonia flowers – by the highest titratable acidity and the least sugar/acid ratio.

Key words: ornamental and medicinal plants, nutraceuticals, antioxidants, polyphenols, carotenoids

INTRODUCTION

Edible flowers have featured as an integral part of human nutrition since antiquity [Kelley et al. 2003, Lim 2014]. They have been traditionally used in cooking in cultures, such as European, Asian, Oriental, Victorian English and Middle East [Kaisoon et al. 2012]. In ancient times flowers were mainly consumed for their pharmacological properties rather than their nutritional value. Nowadays, several studies revealed the chemical compositions of wild and ornamental flowers, showing the presence of important bioactive and nutraceutical compounds including carotenoids, dietary fibres, fatty

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acids, flavonoids, isothiocyanates, phenolic acids, sterols, polyols, prebiotics/probiotics, vitamins, phytoestrogens, essential mineral elements, carbohydrates and amino acids [Kaisoon et al. 2011, Cavaiuolo et al. 2013, Lim 2014, Koike et al. 2015]. The worldwide consumption of edible flowers is increasing [Kelley et al. 2003, Lim 2014]. Flowers are consumed in various forms, colours and flavours to enhance the nutritional and sensory qualities of foods [Lim 2014, Koike et al. 2015]. They are used as a garnish or ingredient in salads, soups, entrees, desserts, and drinks [Kelley et al. 2003]. Some flowers can be stuffed or used in stir-fry dishes [Kaisoon et al. 2012]. There are over 80 species from about 32 families which are classified as edible flowers [Lim 2014]. Among them are ten species compared in the presented study.

Heartsease (*Viola tricolor* L.) belongs to the Violaceae family. The flowers are small and delicate with blue, yellow, purple, pink, white or a combination of colours [Koike et al. 2015]. Heartsease is a well-known medicinal plant [Vukics et al. 2008a]. It is used to treat high blood pressure, indigestion, and skin ailments such as eczema, rashes and inflammation. It can also be used to treat coughs and colds, stiff, sore joints, gout and rheumatoid arthritis [Vukics et al. 2008a, Roberts 2014]. Their biological activities, mainly antioxidant properties, are attributed to the presence of flavonoid compounds with violanthin reported as the major compound [Vukics et al. 2008b, Koike et al. 2015]. *V. tricolor* flowers has a refreshing slight lettuce like taste and velvety texture. They are used as garnishes, in salads, soups, vinegars, drinks and for decorating desserts [Creasy 1999, Koike et al. 2015].

Common daisy (*Bellis perennis* L.) belongs to the Asteraceae family [Gudej and Nazaruk 2001]. It is found in lawns and meadows all over Europe and the Mediterranean and has a long history in folk remedy and medicine [Roberts 2014]. Daisy ray flowers are white or pinkish or in various shades of red and purple [Lim 2014]. The main bioactive constituents of *B. perennis* are phenolic acids, essential oil, triterpene saponins, flavonoids (apigenin, quercetin, kaempferol, isorhamnetin), tannins and mucilage [Avato and Tava 1995, Grabias et al. 1995, Gudej and Nazaruk 2001, Nazaruk and Gudej 2001, Scognamiglio et al. 2012, Morikawa et al. 2015]. Ornamental varieties of *Bellis perennis* daises still contain those components [Roberts 2014]. The plant is frequently utilized for eczema, eye diseases, stomach ache, tonsillitis, common cold, skin boils, as a diuretic, diaphoretic and laxative. It is used in traditional medicine as an expectorant, antispasmotic, antiexudatic, antidepressant, and anti-inflammatory [Gudej and Nazaruk 2001, Nazaruk and Gudej 2001, Lim 2014, Morikawa et al. 2015]. The aerial parts of *B. perennis* are also consumed as a vegetable [Kavalcıoğlu et al. 2010]. The petals of common daisy have a slightly bitter taste and are most commonly used as a garnish sprinkled on salads, soups, sandwiches and steamed vegetables [Creasy 1999, Lim 2014].

Another important genus of the Asteraceae family is marigold (*Tagetes*). Marigolds were used for centuries as a safe medicine. Infusion made of marigold petals is a safe diuretic, flushing toxins from the kidneys and bladder and easing water retention and swollen feet [Roberts 2014]. *Tagetes tenuifolia* has yellow, orange or bicolored flowers, smaller than most other marigolds. The flowers of *Tagetes* species are a rich source of lutein diesters and xanthophylls [Deineka et al. 2007]. Moreover, they are known for the high content of polyphenols. The typical flavonols of this genus are quercetagetin and/or its derivatives [Abdala 2001]. Fresh marigold petals are used in salads and as garnishes [Creasy 1999]. Dried ones can be used in soups, stews, sauces and with mixed spices [Roberts 2014].

Evening primrose (*Oenothera biennis* L.) belongs to the Onagraceae family and it has been used for centuries to treat a wide variety of ailments. It has been used to treat asthma and chest ailments, as a poultice and lotion for bruises and skin disorders, as an infusion for fear, nervousness, panic attacks and anxiety, and for ageing women [Roberts 2014]. Nowadays, evening primrose is generally cultivated as an oil seed crop because its seeds are rich in oil containing γ-linolenic acid (GLA), which is used as a nutritional and medicinal supplement [Zadernowski et al. 2002, Ghasemnezhad and Honermeier 2007]. In cookery, leaves and flowers are added to soups, stews and teas. They are also used for infusions and garnishes [Roberts 2014].

Verbena, a genus of Verbenaceae family, consists of about 200 species worldwide. Cultivated garden verbenas, categorized as *Verbena* × *hybrida*, originate from hybridization among several species. They are popular and important ornamental plants [Tamura et al. 2003]. Verbena flowers can be eaten raw in salads, sandwiches or used as garnishes.

Begonias (Begoniaceae) are one of the most popular bedding plants [Zhang et al. 2010]. *Begonia semperflorens* Link et Otto is widely used according to the advantages such as dwarf plant height with a maximum of 30 cm, nice branching characters, strong disease resistance, and perpetual flowering except for frozen seasons [Chen and Mii 2012]. *Begonia* × *tuberhybrida* is very popular ornamental plant because of its spectacular puffs of orange, yellow, white, pink, or red flowers which are 5 to 10 cm across [Creasy 1999, Lim 2014]. Begonias are known for their anodyne, antiphlogistic, antispasmodic, astringent, ophthalmic, poultice and atomachic activities [Mlcek and Rop 2011]. The brightly coloured flowers of *Begonia* have a delicious, light, lemon taste and crisp texture [Lim 2014]. Their petals are used in salads and sandwiches, and as garnishes [Creasy 1999].

Salvia splendens, belonging to the Lamiaceae family, is a plant originating from Brasil where it is a perennial and is locally used as a medicinal and spice plant [Wu et al. 2009, Błażewicz-Woźniak et al. 2012]. The flowers are red, white, salmon and purple [Wu et al. 2009]. The scarlet flowers of *Salvia splendens* contain salvianin (major), monardaein (minor) and their demalonyl derivatives, whereas the purple flowers of *S. splendens* contain salviadelphin and its demalonyl derivatives as well as dimalonylawobanin [Kondo et al. 1989]. Other phenolic compounds found in *S. splendens* flower are cyanidin-3-glucoside, homogentisic acid and protocatechuic acid [Li et al. 2014].

Borago officinalis L. (Boraginaceae) is an annual herb from the Mediterranean regions which is cultivated for medicinal and culinary uses [Herrmann et al. 2002, Asadi-Samani 2014]. The flowers are blue, white or rose coloured. The main effective substances in this plant are flavonoides, rosmarinic acid, anthocyanins, saponins, unsaturated terpenoides and sterols [Asadi-Samani 2014]. Rich in potassium and calcium, borage tea is both a tonic and a blood purifier. With its high mucilage content (30%) it soothes respiratory ailments, chronic coughs, bronchitis, pleurisy and breaking down mucous [Asadi-Samani 2014, Roberts 2014]. Borage also has a comforting emollient action due to its soothing saponins and tannins, which is helpful for sore, inflamed skin [Roberts 2014]. It is used for the treatment of various diseases such as multiple sclerosis, diabetes, heart diseases, arthritis and eczema [Asadi-Samani 2014]. Traditionally the flowers were made into syrups, wines, taken for coughs and colds and also for anxiety and fear. Borage flowers have a fresh, cucumber-like flavour and can be added to cordials, wines, salads, soups and desserts [Roberts 2014].

Lavandula angustifolia Mill. is a perennial and belongs to the Lamiaceae family [Lim 2014, Seidler-Łożykowska et al. 2014]. Lavender flowers grow in spikes, arranged in circles in the top part of the stem. They are of pale violet colour, although, varieties with white and pink flowers have also been bred [Prusinowska and Śmigielski 2014]. *L. angustifolia* is widely known as an aromatic and medicinal herb [Hajhashemi et al. 2003]. The main components of the aerial parts and flowers of the plant are: linalool (9.3–68.8%), linalyl acetate (1.2–59.4%) and some other mono- and sesquiterpenes; flavonoids (apigenin, ladanein, luteolin); phenolic acids (rosmarinic acid), triterpenoids (ursolic acid); coumarins (umbelliferone, coumarin) [Renaud et al. 2001, Hajhashemi et al. 2003, Wesołowska et al. 2010, Lim 2014, Prusinowska and Śmigielski 2014, Seidler-Łożykowska et al. 2014]. Lavender is known for its antioxidant, neuroprotective, carminative, antimicrobial, anticancer, anti-inflammatory/analgesic, anticonvulsant, anaesthetic, adaptogenic/antistress, menopausal/premenstrual symptom alleviation, antiulcerogenic, spasmolytic, antimutagenic activities, arminative, antiflatulence, antiholic, sedative and antidepressive activities [Hajhashemi et al. 2003, Lim 2014, Seidler-Łożykowska et al. 2014]. Lavender is reported to be an effective medicinal plant in treating inflammation, depression, stress, headache, migraine, gastrointestinal and rheumatic disorders [Hajhashemi et al. 2003, Lim 2014]. Besides its application in herbal treatment, lavender is widely used in the cosmetic, perfume, food and aromatherapeutic industries [Prusinowska and Śmigielski 2014, Seidler-Łożykowska et al. 2014]. Lavender is fragrant and spicy and the flowers (fresh or dried) can be used in both sweet and savoury dishes. Flower petals, flowering tips and leaves are used for flavouring soups, salads, dressings, sauces, jams, stews, vinegar, sorbets, caramel custard, cakes, ice cream and jellies [Lim 2014]. Lavender can be used in tea, lemonade and vinegars and to flavour sugar. The fresh flowers are also crystallized. Traditionally lavender buds are one of the many flavorings of the French herb blend called *Herbes de Provence* [Creasy 1999].

The aim of our study was to compare the biological value of *Borago officinalis, Lavandula angustifolia*, *Oenothera biennis*, *Viola tricolor*, *Bellis perennis* (white and pink flowers), *Salvia splendens*, *Tagetes tenuifolia*, *Verbena × hybrid*, *Begonia semperflorens* and *Begonia × tuberhybrida* flowers.

MATERIAL AND METHODS

The experiment was carried out at 'The Edible Flower Collection' of the Department of Horticulture of the West Pomeranian University of Technology in Szczecin, in 2010–2011. The laboratory part of the experiment was conducted in the laboratory of the Department of Horticulture of the West Pomeranian University of Technology in Szczecin. The research material consisted of borage (*Borago officinalis* L.) – whole flowers; lavender (*Lavandula angustifolia* Mill.) – buds with violet petals; evening primrose (*Oenothera biennis* L.) – whole flowers; heartsease (*Viola tricolor* L.) – whole flowers; white and pink common daisy – ray flowers (*Bellis perennis* L.); scarlet sage cv. Torreador (*Salvia splendens* Sellow ex Roem. et Shult.) – petals; signet marigold cv. Lulu (*Tagetes tenuifolia* Cav.) – ray flowers; garden verbena cv. Estrella Voodoo Red (*Verbena × hybrida*) – whole flowers; wax begonia cv. Juwel F1 White (*Begonia sem-*

perflorens Link et Otto) – whole white flowers; tuberous begonia cv. Tubby F1 White (*Begonia* × *tuberhybrida* Voss.) – whole white flowers.

Mineral fertilization was quantified according to the results of chemical analysis of the soil. The fertilization was adjusted to the proper requirements for the species according to Startek and Mynett [2003], and Kołodziej [2010]. During the growing season crop management was carried out. It included mainly irrigation, weeding and soil cultivation.

The flower harvest was done at full-bloom stage (heartsease, daisies – in the beginning of June; garden verbena, wax begonia – in the beginning of July; borage, lavender, evening primrose, scarlet sage, signet marigold, tuberous begonia – in the middle of July). The chemical analyses of raw plant material included the determination of the content of dry matter (drying at 105ºC to constant weight), total chlorophyll, chlorophyll a and b [Lichtenthaler and Wellburn 1983], vitamin C as L-ascorbic acid (by the method of Tillmans), total carotenoids [Lichtenthaler and Wellburn 1983] and total polyphenols – by spectrophotometer, using gallic acid as reference, and Follin-Ciocalteu reagent [Singleton and Rossi 1965]. Antioxidant activity of the edible flowers on DPPH-radical was determined using the Yen and Chen method [1995]. Raw homogenised material was diluted 400 times in 100% methanol. DPPH percent inhibition was calculated according to Rossi et al. [2003]. Moreover, the content of total soluble sugars, reducing sugars and saccharose (by the method of Luff-Schoorl), titratable acidity [Krełowska-Kułas 1993], total ash (incineration of samples in 500ºC), crude fibre [Klepacka 1996], total nitrogen (by the method of Kjeldahl) and total protein (using factor 6.25 for the determined total nitrogen amount), were determined. We also calculated sugar to acid ratio (total soluble sugars / titratable acidity).

The results of the study were subjected to an analysis of variance which was performed with AWAR software, made by the Department of Applied Informatics, Institute of Soil Science and Plant Cultivation in Puławy. The means were separated by the Tukey's test at $p = 0.05$.

RESULTS AND DISCUSSION

The results given in tables 1–4 were expressed as an average of a two-year experiment. The data given in Table 1 show that among the experiment species the highest content of dry matter was found for lavender (34.01%) and garden verbena (32.24%) flowers, while the least for begonia flowers – *B. semperflorens* (7.16%) and *B. tuberhybrida* (3.75%). Rop et al. [2012] assessed dry matter content for 12 other species of edible flowers and it ranged from 8.37% for *Fuchsia* × *hybrida* up to 14.75% for *Impatiens walleriana*. Grzeszczuk et al. [2011] for edible flowers of chive recorded 20.01% of dry matter, and Seroczyńska et al. [2006] for winter squash flowers – 65.2–78.1%. Moreover, Ghasemnezhad and Honermeier [2007] recorded 18.6% of dry matter in the evening primrose herb; in our study we assessed dry matter content of evening primrose flowers and it was 12.79%. In the presented study, flowers of both species of begonia were also characterized by the least content of chlorophylls (total, a and b). For tuberous begonia flowers we determined 0.021 $\mu g \cdot g^{-1}$ f.w. of total chlorophylls and for wax begonia – 0.009 $\mu g \cdot g^{-1}$ f.w. The highest content of chlorophylls was noted for heartsease (1.363 μg of total chlorophylls per g f.w.), lavender (0.556 $\mu g \cdot g^{-1}$) and borage (0.406 $\mu g \cdot g^{-1}$), which is due to the green parts of the flowers taken for the analyses.

Table 1. Content of dry matter and chlorophylls in various edible flower species (mean values from years 2010–2011)

Edible flower species	Dry matter (%)	Chlorophyll (μg·g^{-1} f.w.)		
		total	a	b
Borago officinalis L.	15.19	0.406	0.232	0.137
Lavandula angustifolia Mill.	34.01	0.556	0.320	0.194
Oenothera biennis L.	12.79	0.056	0.033	0.018
Viola tricolor L.	31.53	1.363	0.877	0.329
Bellis perennis L. / white flowers	15.97	0.065	0.041	0.021
Bellis perennis L. / pink flowers	18.63	0.116	0.061	0.044
Salvia splendens Sellow ex Roem. et Shult.	11.87	0.091	0.027	0.045
Tagetes tenuifolia Cav.	17.11	0.105	0.052	0.043
Verbena × hybrida	32.24	0.222	0.101	0.086
Begonia semperflorens Link et Otto	7.16	0.009	0.005	0.003
Begonia × tuberhybrida Voss.	3.75	0.021	0.014	0.005
$LSD_{\alpha = 0.05}$	2.211	0.137	0.071	0.068

Table 2. Content of L-ascorbic acid, total carotenoids, total polyphenols and antioxidant activity of various edible flower species (mean values from years 2010–2011)

Edible flower species	L-ascorbic acid (mg·100 g^{-1} f.w.)	Total carotenoids (μg·g^{-1} f.w.)	Total polyphenols (mg·100 g^{-1} f.w.)	Antioxidant activity (% DPPH)
Borago officinalis L.	29.84	0.078	197.85	13.93
Lavandula angustifolia Mill.	37.52	0.164	472.63	31.70
Oenothera biennis L.	40.71	0.204	518.10	59.91
Viola tricolor L.	182.16	0.426	974.50	38.07
Bellis perennis L. / white flowers	14.40	0.026	308.18	18.91
Bellis perennis L. / pink flowers	10.56	0.079	447.35	38.57
Salvia splendens Sellow ex Roem. et Shult.	45.84	0.036	216.24	6.47
Tagetes tenuifolia Cav.	241.20	0.992	1362.09	84.95
Verbena × hybrida	82.32	0.052	809.03	38.00
Begonia semperflorens Link et Otto	20.16	0.030	448.77	25.63
Begonia × tuberhybrida Voss.	41.52	0.020	100.87	3.63
$LSD_{\alpha = 0.05}$	50.445	0.079	98.207	6.768

Table 3. Content of total soluble sugars, reducing sugars, saccharose, titratable acidity and sugar/acid ratio of various edible flower species (mean values from years 2010–2011)

Edible flower species	Total soluble sugars (% f.w.)	Reducing sugars (% f.w.)	Saccharose (% f.w.)	Titratable acidity (% cictric acid f.w.)	Sugar/ acid ratio
Borago officinalis L.	3.08	2.53	0.523	0.107	28.79
Lavandula angustifolia Mill.	3.70	3.11	0.561	0.398	9.30
Oenothera biennis L.	2.02	2.00	0.019	0.252	8.02
Viola tricolor L.	3.24	2.55	0.656	0.548	5.91
Salvia splendens Sellow ex Roem. et Shult.	0.71	0.53	0.171	0.190	3.74
Begonia semperflorens Link et Otto	0.21	0.19	0.019	0.814	0.26
$LSD_{\alpha = 0.05}$	0.208	0.160	0.187	0.125	6.931

Table 4. Content of total ash, crude fibre, total nitrogen and total protein in various edible flower species (mean values from years 2010–2011)

Edible flower species	Total ash (% f.w.)	Crude fibre (% f.w.)	Total nitrogen (% f.w.)	Total protein (% f.w.)
Borago officinalis L.	2.23	2.32	0.36	2.19
Lavandula angustifolia Mill.	2.47	5.96	0.63	3.91
Oenothera biennis L.	0.92	1.22	0.23	1.40
Viola tricolor L.	5.25	2.64	0.67	4.19
Bellis perennis L. / white flowers	1.53	0.18	1.15	7.16
Bellis perennis L. / pink flowers	2.17	0.54	0.89	5.53
Salvia splendens Sellow ex Roem. et Shult.	1.34	1.49	1.52	9.51
Begonia semperflorens Link et Otto	1.90	1.35	0.14	0.88
$LSD_{\alpha = 0.05}$	0.365	0.490	0.062	0.378

The analysis of the results of bioactive compound contents showed that signet marigold with its bright yellow flowers was characterized by the highest biological value in comparison with the other species (tab. 2). The flowers contained 241.20 mg·100 g^{-1} f.w. of L-ascorbic acid, 0.992 μg·g^{-1} f.w. of total carotenoids, 1362.09 mg GAE·100 g^{-1} f.w. of total polyphenols, and their antioxidant activity was 84.95% DPPH. The content of total carotenoids which we assessed is comparable with the results obtained by Deineka et al. [2007]. With the yellow flowers of marigold they determined 1 mg·g^{-1} f.w. of carotenoids. They also noted that the content of carotenoids in marigold with orange flowers exceeds 5 mg per gram of fresh petals, against 0.2 mg·g^{-1} f.w. for lemon-yellow flowers. There is a lack of data for the content of total polyphenols in *T. tenuifolia* flowers. Although, for *T. erecta* flowers it was recorded 14.139 mg CE·g^{-1} d.w. [Zeng et al. 2014] and 212.9 mg GAE·g^{-1} d.w. [Kaisoon et al. 2012, Lim 2014], and for *T. patula* – 4.58 mg of total phenolics per gram of f.w. [Cavaiuolo et al. 2013]. High content of L-ascorbic acid, total carotenoids and total polyphenols we also noted for heartsease, it was respectively: 182.16 mg·100 g^{-1} f.w., 0.426 μg·g^{-1} f.w. and 974.50 mg GAE·100 g^{-1} f.w. In the study of Koike et al. [2015], the antioxidant activity of *Viola tricolor* flowers was 2.0 mg GAE per g of methanol/water extracts. In the literature we can find data for polephenols content for three other species which were also analysed in our study. Zeng et al. [2014] recorded 20.426 mg CE (catechin equivalents) per g of d.w. for *Lavandula angustifolia*. In the study of Zangenehgheshlaghi et al. [2012] the total phenolic content in daisy flowers amounted from 20 up to 25 mg GAE·g^{-1} d.w., according to applied vermicompost rates. Our results expressed in dry weight were similar – 19.30 mg GAE·g^{-1} d.w. for white petal daises and 24.01 mg GAE·g^{-1} d.w. for the pink ones. For scarlet salvia we recorded 216 mg GAE·100 g^{-1} f.w. which was quite similar to the result obtained by Li et al. [2014] – 2.57 mg GA·g^{-1} f.w.

For six of the edible flower species (borage, lavender, evening primrose, heartsease, scarlet sage, wax begonia) we also determined the content of total soluble sugars, reducing sugars, saccharose, titratable acidity and sugar to acid ratio – important characteristic from the consumer point of view (tab. 3). The highest content of sugars (total soluble, reducing and saccharose) were found in flowers of lavender (respectively: 3.70, 3.11, 0.561% f.w.), heartsease (3.24, 2.55, 0.656% f.w.) and borage (3.08, 2.53, 0.523% f.w.) while the least was for wax begonia flowers (0.21, 0.19, 0.019% f.w.). The highest titratable acidy was recorded for wax begonia (0.814% citric acid f.w.) > heartsease (0.548) > lavender (0.398), while the least for scarlet sage (0.190) and borage (0.107). Therefore, it resulted in the highest sugar/acid ratio for borage flowers and the least was for wax begonia flowers which agreed with the taste of these flowers described in literature: borage – cucumber taste of petals with a hint of sweetness added by stamens, wax begonia – lemon/sour-citrus taste [Roberts 2014].

For some of the species (borage, lavender, evening primrose, heartsease, daises, scarlet sage, wax begonia) we also determined the content of total ash, crude fibre, total nitrogen and total protein (tab. 4). On the basis of the obtained results it was found that lavender flowers were characterized by the highest content of crude fibre (5.96% f.w.) and scarlet sage – the highest content of total nitrogen (1.52% f.w.) and total protein (9.51% f.w.). Moreover, the highest content of total ash, which provides a measure of the total amount of minerals, was recorded for heartsease flowers (5.25% f.w.). In the opinion of Rop et al. [2012] edible flowers are an excellent source of minerals, especially of phosphorus and potassium. The contents of these elements in flowers of 12 species which they have tested, ranged from 202.11 to 514.62 $mg \cdot kg^{-1}$ of f.w. and from 1,842.61 to 3,964.84 $mg \cdot kg^{-1}$ of f.w., respectively. The highest amounts of mineral compounds were observed in the flowers of *Chrysanthemum*, *Dianthus* and *Viola*.

CONCLUSIONS

1. The edible flowers are a rich source of nutritional and bioactive compounds.
2. Among the tested edible flowers *Tagetes tenuifolia* had the highest content of biologically active compounds – L-ascorbic acid, total carotenoids, total polyphenols, and the highest antioxidant activity.
3. High biological value was also noted for the flowers of *Viola tricolor* – the highest total ash, saccharose, and chlorophyll content; *Lavandula angustifolia* – the highest content of dry matter, crude fibre, total soluble and reducing sugars; and *Salvia splendens* – the highest content of total nitrogen and total protein; while the least was for *Begonia* flowers.

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WARTOŚĆ BIOLOGICZNA WYBRANYCH GATUNKÓW KWIATÓW JADALNYCH

Streszczenie. Kwiaty jadalne już od wieków są wykorzystywane kulinarnie oraz cenione z uwagi na ich wysoką wartość biologiczną i sensoryczną. Celem niniejszej pracy było porównanie wartości biologicznej kwiatów *Borago officinalis*, *Lavandula angustifolia*, *Oenothera biennis*, *Viola tricolor*, *Bellis perennis*, *Salvia splendens*, *Tagetes tenuifolia*, *Verbena* × *hybrid*, *Begonia semperflorens* oraz *Begonia* × *tuberhybrida*. Spośród porównywanych w doświadczeniu gatunków kwiatów jadalnych istotnie największą zawartością związków biologicznie czynnych (kwasu L-askorbinowego, karotenoidów ogółem, polifenoli ogółem) oraz aktywnością antyoksydacyjną wyróżniały się kwiaty aksamitki wąskolistnej. Kwiaty fiołka trójbarwnego charakteryzowały się natomiast istotnie większą zawartością popiołu ogólnego, sacharozy oraz barwników chlorofilowych. Istotnie większą zawartość suchej masy, błonnika surowego, cukrów rozpuszczalnych ogółem oraz cukrów redukujących oznaczono w kwiatach lawendy wąskolistnej, zaś azotu ogólnego i białka ogółem – w kwiatach szałwii błyszczącej. Istotnie największą kwasowością ogólną odznaczały się kwiaty begonii stale kwitnącej, które charakteryzował również najmniejszy stosunek cukrów ogółem do kwasowości ogólnej.

Słowa kluczowe: rośliny ozdobne i lecznicze, składniki odżywcze, antyoksydanty, polifenoli, karotenoidy

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