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Original Article

Nutritional and Biological Value of Five Edible Flower Species

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Abstract

The introduction of edible flowers into our menu and their consumption significantly increases as a result of decorative, taste or aroma qualities. Current research on the chemical composition of edible flowers indicates a high content of vitamins, mineral compounds, essential oils, fibre, mucilage and other compounds characterized by a very high antioxidant activity. The aim of the experiment was to compare the nutritional value and antioxidant activity of three annual and two perennial ornamental plant species with edible flowers: *Mimulus* x *hybridus* L. 'Magic Yellow' and 'Magic Red', *Antirrhinum majus* L. 'Cavalier', *Dianthus chinensis* L. 'Chianti', *Hemerocallis* x *hybrida* Hort. and *Monarda didyma* L. Among the edible flower species compared in the study, *M. didyma* L. showed the highest nutritional value and antioxidant activity (DPPH and ABTS). While flowers of *D. chinensis* L. 'Chianti' were characterized by highest content of antioxidants such as L-ascorbic acid, total anthocyanins, total polyphenols and ferric reducing antioxidant power (FRAP), *H.* × *hybrida* and *A. majus* L. 'Cavalier' flowers – by the highest content of total soluble sugars and sugar/acid ratio, and *M.* × *hybridus* L. 'Magic Red' and 'Magic Yellow' – by the highest content of total carotenoids.

Keywords: *Mimulus*; *Antirrhinum*; *Dianthus*; *Hemerocallis*; *Monarda*; chemical composition; antioxidants

Introduction

Flowers described in the literature as a wonder of nature and a symbol of beauty is an integral part of many people's lives. Moreover, many of the ornamental plant species are edible (Chen and Wei, 2017). For centuries used in culinary art, edible flowers are part of many regional cuisines, including Asian, European and Middle Eastern (Kaisoon *et al*., 2012; Fernandes *et al*., 2017). Flowers can be used as a main ingredient of a dish or as a garnish. They are very popular compounds of such products as liqueurs, vinegars, honeys and oils (Husti *et al*., 2013; Cunningham, 2015; Petrova *et al*., 2016). In European countries, the most common use of edible flowers in human nutrition is the preparation of hot beverages. We drink infusions or decoctions, because of their medicinal properties but moreover due to their sensory qualities (Navarro-González *et al*., 2015; Ngoitaku *et al*., 2016). Edible flowers have a great impact on color, flavor and appearance of our drinks and dishes (Kelley *et al*., 2001). In the past, they were mainly consumed for their medicinal properties (Cavaiuolo *et al*., 2013; Huang *et al*., 2017). Whereas recently scientists underline also their nutritional value (Cavaiuolo *et al*., 2013; Lu *et al*., 2015; Huang *et al*., 2017). The results of their studies show low caloric value, high content of vitamins, mineral compounds, essential oils, fibre, mucilage and other compounds characterized by a very high antioxidant activity (Rop *et al*., 2012; Deepika *et al*., 2014; Navarro-González *et al*., 2015; Grzeszczuk *et al*., 2016). As scientists suggest, due to the high content of these active ingredients, edible flowers can potentially be used to prevent chronic diseases (Chen *et al*., 2015; Dhiman *et al*., 2017; Pires *et al*., 2017; Wang *et al*., 2017). Edible flowers have wide medicinal properties, including: anticancer, antidiabetic, anti-inflammatory, diuretic and antibacterial (Petrova *et al*., 2016). Flowers of many ornamental plant species are also a rich source of antioxidants capable of removing the negative effects of free radicals (Li *et al*., 2014; Ngoitaku *et al*., 2016). In humans, antioxidants play an important role in the prevention of several degenerative and stress-related diseases (Xiong *et al*., 2014; Dhiman *et al*., 2017). Antioxidants, such as vitamin C (L-ascorbic acid), carotenoids, anthocyanins and polyphenols, often appear in flowers at higher concentrations compared to common fruit or vegetables (Bor *et al*., 2006; Mlcek and Rop, 2011; Cavaiuolo *et al*., 2013).

More and more often we see that edible flowers are a new direction of healthy nutrition (Mlcek and Rop, 2012; Benvenuti *et al*., 2016). Unfortunately, dishes with fresh flowers are still a challenge for most consumers, including chefs, because the knowledge about their nutritional value is

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still limited (Kelley *et al*., 2001; Rodrigues *et a*l., 2017). The aim of our study was to assess the content of some nutritional compounds and antioxidant activity of selected species with edible flowers: *Mimulus* × *hybridus* L. 'Magic Yellow' and 'Magic Red', *Antirrhinum majus* L. 'Cavalier', *Dianthus chinensis* L. 'Chianti', *Hemerocallis* × *hybrida* Hort. and *Monarda didyma* L.

Materials and Methods

Plant material

The experiment was carried out in the years 2014-2016 at 'The Edible Flower Collection' of the Department of Horticulture of the West Pomeranian University of Technology in Szczecin. 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 three annual and two perennial ornamental plant species with edible flowers: *Mimulus* × *hybridus* L. 'Magic Yellow' and 'Magic Red' – yellow and red petals, respectively; *Antirrhinum majus* L. 'Cavalier' – orange-pink petals; *Dianthus chinensis* L. 'Chianti' – dark maroon/almost black, white edged petals; *Hemerocallis* × *hybrida* Hort. – orange-yellow petals; *Monarda didyma* L. – bilabiate, carmine red flowers gathered in 1-3 whorls with reddish bracts (Grzeszczuk *et al*., 2018).

The experimental plot area was: 1.8 m^2 for *M.* × *hybridus* cultivars (30×30 cm, 20 plants per plot), 5.76 m^2 – *A. majus* (30×30 cm, 64 plants per plot), 4.32 m^2 – *D. chinensis* (30×30 cm, 48 plants per plot), 2.4 m^2 – *H.* × *hybrida* (120×100 cm, 2 plants per plot) and 2.16 m^2 for *M. didyma* (60×60 cm, 6 plants per plot). The planting material of *M.* × *hybridus* was bought in an ornamental plant nursery and planted on the experimental plots on the 19th May 2014 and on the 20th May 2015. The seedlings of *A. majus* and *D. chinensis* were produced in the greenhouse. Seeds were sown on the 17th March 2014 and 2015. The seedlings were transplanted into the open field on the 19th May 2014 and on the 21st May 2015. The planting material of *H.* × *hybrida* was bought in an ornamental plant nursery and planted on the experimental plots on the 19th May 2014. The seedlings of *M. didyma* were produced in the greenhouse. Seeds were sown on the 22th April 2014. The seedlings were transplanted into the open field on the 18th August 2014. The flowers of *M. didyma* were collected the following two years (2015 and 2016).

The field was prepared according to the proper agrotechnical procedure for the tested species plants (Newerli-Guz, 2016). Mineral fertilization was quantified according to the results of the chemical analysis of the soil. During the field work in all years of the study mineral fertilization, in the form of NPK in amounts: 50:50:80 kg ha^{-1}, was applied. Agrotechnique included mainly irrigation, weeding and soil cultivation.

The flower harvest was done at full-bloom stage (*M.* × *hybridus* – in the middle of June; *A. majus*, *D. chinensis*, *H.* × *hybrida* – at the beginning of July, *M. didyma* – in the middle of July). An aggregate sample from the four field replications weighed from 50 to 150 g, depending on a plant species.

Laboratory analysis

The chemical analyses of raw plant material included the determination of the content of dry matter (drying at 105 °C to constant weight), total ash (incineration of samples in 500 °C), crude fibre (Klepacka, 1996) and total protein (using factor 6.25 for the determined total nitrogen amount by the method of Kjeldahl). Moreover, the content of total soluble sugars, reducing sugars and saccharose (by the method of Luff-Schoorl), and titratable acidity (ISO 750, 1998) were determined. The sugar to acid ratio (total soluble sugars / titratable acidity) was calculated, too. The experiment was also concerned about the content of total chlorophylls, 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 anthocyanins (Lee *et al*., 2005; Anuar *et al*., 2013). All the determinations were carried out in three replicates.

Preparation of plant extracts for total polyphenol content and antioxidant activity determination

The preparation of plant extracts was performed using the method proposed by Wojdyło *et al*. (2007) with some modifications. The sample of 1 g homogenised raw plant material was treated with 80% aqueous methanol (MeOH) to 100 ml volume. The mixtures were placed in an ultrasonic bath at room temperature and sonicated for 30 minutes (2 × 15 minutes) and then left for 24 hours at room temperature. The obtained extracts were filtered through Whatman No. 1 filter paper. The filtrates were centrifuged at 1500 rpm for 10 minutes. All the extractions were carried out in three replicates. The extracts were kept in 4 °C and used for the analyses within 24 hours.

Determination of total polyphenol content

Total polyphenol content was analysed spectrophotometrically using the Folin-Ciocalteu colorimetric method as described by Wojdyło *et al*. (2007). The plant extract (100 μl) was mixed with 0.2 ml of the Folin-Ciocalteu reagent, 2 ml of distilled water and 1 ml of 20% sodium carbonate. The samples were allowed to stand for 1 hour at room temperature in darkness. Then the absorbance was measured at 760 nm. Gallic acid (GAE) was used to calculate the standard curve, and the results were expressed as GAE milligrams per g of fresh weight (FW).

Determination of DPPH radical scavenging capacity

The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging capacity was evaluated according to the procedure of Kumaran and Karunakaran (2007) and Wojdyło *et al*. (2007). DPPH (0.3 mM) was dissolved in pure ethanol (99.8%). The plant extract (0.6 ml) was added to 1.8 ml of pure ethanol (EtOH) and 0.6 ml of DPPH solution. The samples were incubated at room temperature for 10 minutes in the dark. The reduction of the DPPH radical was determined spectrophotometrically by measuring the absorption at 517 nm. Trolox (TE, 6-

hydroxy-2,5,7,8-tetramethylchromane-2-carboxylic acid) was used for calibrating the standard curve and the results were expressed as mg of trolox equivalent antioxidant capacity per g of fresh weight sample (mg TE g^{-1} FW).

Determination of ferric reducing antioxidant power (FRAP)

The total antioxidant potential of the samples was determined using the ferric reducing ability of plasma FRAP assay by Wojdyło *et al*. (2007) as a measure of antioxidant power. The FRAP reagent was prepared by mixing an acetate buffer (300 mM, pH 3.6), a solution of 10 mM TPTZ (2,4,6-tris(2-pyridyl)-s-triazine) in 40 mM HCl, and 20 mM $FeCl_3 \cdot 6H_2O$ (iron(III) chloride hexahydrate) at 10:1:1 (v/v/v), and warmed at 37 °C before using. For the spectrophotometric assay, 2.7 ml of the reagent and 0.3 m of the sample solution were mixed. The absorbance was taken at 593 nm after 4 minutes. The standard curve was prepared using different concentrations of trolox. The results were expressed in mg TE per g FW.

Determination of free radical-scavenging ability by the use of a stable ABTS radical cation

The free radical-scavenging activity was determined by the ABTS radical cation decolourisation procedures described by Re *et al*. (1999), Chew *et al*. (2007) and Wojdyło *et al*. (2007) with some modifications. ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt was dissolved in distilled water to a 7 mM concentration. The ABTS radical cation ($ABTS^{\bullet+}$) was produced by reacting the ABTS stock solution with 2.45 mM potassium peroxodisulfate and kept in darkness at room temperature for 16 hrs before use. The $ABTS^{\bullet+}$ solution was diluted with PBS (phosphate buffered saline, pH 7.4) until its absorbance was equilibrated to 0.7 (± 0.02) at 734 nm before usage. After the addition of 3.0 ml of the diluted $ABTS^{\bullet+}$ solution (A_{734}= 0.7± 0.02) to 300 µl of methanolic plant extracts, the absorbance reading was taken, exactly 6 minutes after initial mixing. Trolox was used for calibrating the standard curve and the results were expressed as mg TE per g FW.

Statistical analysis

The results of the study were subjected to an analysis of variance which was performed with AWAR software, made by the Department of Agrometeorology and Applied Informatics, Institute of Soil Science and Plant Cultivation in Puławy, Poland (Filipiak and Wilkos, 1995). The means were separated by the Tukey's test at p = 0.05.

Results and Discussion

The results of the experiment were given in Tab. 1-5 and presented as means from the years 2015-2016 for *Monarda didyma* L. and from the years 2014-2015 – for the other species.

The data given in Table 1 shows that among the tested species a significantly higher content of dry matter was noted for the flowers of *Monarda didyma* L. (18.85%), *Dianthus chinensis* L 'Chianti' (18.05%), and *Antirrhinum majus* L. 'Cavalier' (13.82%), while significantly lower – for *Hemerocallis* × *hybrida* Hort. (9.97%) and *Mimulus* × *hybridus* L. flowers ('Magic Yellow' – 6.68%, 'Magic Red' 7.40%). The dry matter content assessed by Rop *et al.* (2012) for some edible flower species was lower in comparison with our results. For *Antirrhinum majus* flowers they determined 12.61% of dry matter, and for *Dianthus caryophyllus* flowers – 11.55%. However, there are edible flowers which are characterized by higher dry matter content than those tested in our experiment. Seroczyńska *et al.* (2006) for edible flowers of winter squash recorded 65.2-78.1% of dry matter, Grzeszczuk *et al.* (2016) for lavender – 34.01% and garden verbena – 32.24%. In another study Grzeszczuk *et al.* (2011) determined 20.01% of dry matter in chive flowers.

On the basis of the obtained results it was found that *Monarda didyma* L. flowers were characterized by the highest content of total ash (1.564% FW), crude fibre (1.927% FW) and total protein (7.817% FW). In the study of Grzeszczuk *et al.* (2016) on other species of edible flowers it was shown that they contained from 0.92 (*Oenothera biennis* L.) to 5.25% FW (*Viola tricolor* L.) of total ash, from 0.18 (*Bellis perennis* L.) to 5.96% FW (*Lavandula angustifolia* Mill.) of crude fibre and from 0.88 (*Begonia semperflorens* Link et Otto) to 9.51% FW (*Salvia splendens* Sellow ex Roem. et Shult.) of total protein. Navarro-González *et al.* (2015) recorded in the flowers of *Tropaeolum majus, Tagetes erecta* and *Spilanthes oleracea* from 0.63 to 1.44% FW of ash and from 1.32 to 2.83% FW of protein.

Flavor of edible flowers is related to the content of sugars and acids (Kaack *et al.*, 2005). The content of total soluble sugars, reducing sugars, saccharose, titratable acidity and sugar/acid ratio differed significantly according to the species and cultivar of the tested ornamental plant (Table 2).

Table 1. Content of dry matter, total ash, crude fibre and total protein (% FW) in selected edible flower species

Species and cultivar name	Dry matter	Total ash	Crude fibre	Total protein
Mimulus × *hybridus* L. 'Magic Yellow'	6.68±0.42 c	0.533±0.08 c	0.635±0.09 d	1.727±0.65 e
Mimulus × *hybridus* L. 'Magic Red'	7.40±0.34 c	0.671±0.09 c	0.722±0.01 cd	1.865±0.41 e
Hemerocallis × *hybrida* Hort.	9.97±0.04 bc	0.503±0.00 c	0.491±0.13 d	3.346±0.38 c
Antirrhinum majus L. 'Cavalier'	13.82±0.01 ab	0.637±0.00 c	0.961±0.02 c	2.692±0.88 d
Dianthus chinensis L. 'Chianti'	18.05±0.62 a	1.125±0.30 b	1.468±0.13 b	5.610±0.84 b
Monarda didyma L.	18.85±0.18 a	1.564±0.12 a	1.927±0.19 a	7.817±0.68 a
$LSD_{\alpha=0.05}$	4.351	0.262	0.323	0.273

Table 2. Content of total soluble sugars, reducing sugars, saccharose and titratable acidity in selected edible flower species

Species and cultivar name	Total soluble sugars (% FW)	Reducing sugars (% FW)	Saccharose (% FW)	Titratable acidity (% citric acid FW)	Sugar/ acid ratio
Mimulus × *hybridus* L. 'Magic Yellow'	1.48±0.00 e	1.55±0.08 c	0.29±0.19 b	0.27±0.00 c	6.32±0.77 c
Mimulus × *hybridus* L. 'Magic Red'	2.25±0.25 d	1.87±0.62 c	0.25±0.15 b	0.32±0.00 bc	6.29±0.40 c
Hemerocallis × *hybrida* Hort.	5.60±0.00 a	4.92±0.22 a	0.27±0.17 b	0.31±0.11 bc	18.08±1.72 a
Antirrhinum majus L. 'Cavalier'	5.55±0.37 a	4.00±0.20 b	1.07±0.22 a	0.29±0.05 c	17.99±0.83 a
Dianthus chinensis L. 'Chianti'	4.56±0.34 b	4.70±0.25 a	0.09±0.01 b	0.35±0.12 b	16.08±0.41 b
Monarda didyma L.	2.84±0.00 c	1.75 c±0.29	0.64±0.14 ab	0.71±0.29 a	3.79±0.23 d
$LSD_{\alpha=0.05}$	0.529	0.605	0.606	0.053	1.787

The highest content of total soluble sugars and sugar/acid ratio were found in the flowers of *Hemerocallis* × *hybrida* Hort. (respectively: 5.60% FW, 18.08) and *Antirrhinum majus* L. 'Cavalier' (5.55% FW, 17.99) while the least content of total soluble sugars was noted for *Mimulus* × *hybridus* L. 'Magic Yellow' flowers (1.48% FW) and the least sugar/acid ratio – for *Monarda didyma* L. flowers (3.79). The highest content of reducing sugars was noted for *Hemerocallis* × *hybrida* Hort. (4.92% FW) and *Dianthus chinensis* L. 'Chianti' flowers (4.70% FW). Moreover, the flowers *Antirrhinum majus* L. 'Cavalier' and *Monarda didyma* L. were characterized by a significantly higher content of saccharose (respectively: 1.07 and 0.64% FW). When comparing the titratable acidity, it was shown that its highest value was found in flowers of *Monarda didyma* L. (0.71% citric acid FW). Grzeszczuk *et al.* (2016) the highest content of sugars (total soluble, reducing and saccharose) determined in the flowers of lavender (respectively: 3.70, 3.11, 0.561% FW), heartsease (3.24, 2.55, 0.656% FW) and borage (3.08, 2.53, 0.523% FW) while the least was noted for wax begonia flowers (0.21, 0.19, 0.019% FW). The highest titratable acidity was recorded for wax begonia, heartsease and lavender (respectively: 0.814, 0.548, 0.398% citric acid FW) while the least for scarlet sage and borage (0.190, 0.107% citric acid FW). The flavor of the edible flowers compared in our study was described in the literature as: bitter-salty – *Mimulus*; sweetish/flowerish – *Hemerocallis*; bitter – *Anthirrhinum majus*; spicy-sweet/slightly bitter – *Dianthus*; citrus/minty – *Monarda* (Mlcek and Rop, 2011; Ghosh, 2013; Husti *et al.*, 2013; Deepika *et al.*, 2014; Stefaniak and Grzeszczuk, 2015; Benvenuti *et al.*, 2016). It is in agreement with the results of our study, where flowers of *Hemerocallis* x *hybrida* Hort. and *Dianthus chinensis* L. 'Chianti' were characterized by a very high sugar content and sugar/acid ratio while the flowers of *Monarda didyma* L. – by the highest titratable acidity.

The highest content of total chlorophylls was noted in flowers from *Monarda didyma* L. (461.67 μg g^{-1} FW) and *Dianthus chinensis* L. 'Chianti' (369.78 μg g^{-1} FW) (Table 3). Moreover, *Monarda didyma* L. flowers were characterized by the highest content of chlorophyll a (312.74 μg g^{-1} FW), while flowers of *Dianthus chinensis* L. 'Chianti' – by the highest content of chlorophyll b (257.09 μg g^{-1} FW). Petrova *et al.* (2016) examined five edible flower species. Among the 95% ethanol flower extracts, the one made of *Geranium macrorrhizum* L. flowers was found as the richest source of total chlorophylls – 41.5 μg g^{-1} FW.

Vitamin C, carotenoids and polyphenols are considered as the most important antioxidants (Li *et al.*, 2014; Zhang *et al.*, 2015). The main polyphenol compounds determined in edible flowers are: phenolic acid derivatives (chlorogenic, caffeic and p-coumaric acids) and flavonoids (e.g. kaempferol, quercetin, apigenin, naringenin, hesperetin, luteolin) (Skrajda, 2017; Chen *et al.*, 2018; Pires *et al.*, 2018). One of the largest flavonoid group responsible for the red, purple and blue colors of fruits, vegetables and flowers are anthocyanins (cyanidin, delphinidin, pelargonidin, peonidin, malvidin and petunidin) (Martín *et al.*, 2017). In the presented study flowers of *Dianthus chinensis* L. 'Chianti' were characterized by the highest content of L-ascorbic acid (89.78 mg $100g^{-1}$ FW) and total anthocyanins (443.47 mg C3G $100g^{-1}$ FW), while the flowers of *Mimulus* x *hybridus* L. cultivars – by the highest content of total carotenoids ('Magic Red' – 529.68 and 'Magic Yellow' – 473.42 μg g^{-1} FW. Higher content of L-ascorbic acid was determined by Grzeszczuk *et al.* (2016) in the flowers of *Tagetes tenuifolia* Cav. – 241.20 mg $100g^{-1}$ FW. Garzón and Wrolstad (2009) determined 71.5 mg 100 g^{-1} FW. for *Tropaeolum majus* flowers. In the literature we can find data of total carotenoids content of some edible flower species. Seroczyńska *et al.* (2006) recorded 1.23-18.79 mg of carotenoids per 100 g FW for winter squash flowers, Petrova *et al.* (2016) – 57.2 μg g^{-1} FW for *Calendula officinalis* L. and Loizzo *et al.* (2016) – 3.4 mg g^{-1} FW for *Capparis spinosa*. The content of anthocyanins of *Antirrhinum majus* L. which we assessed was higher in comparison with the results obtained by Benvenuti *et al.* (2016). They determined for *Antirrhinum majus* L. with flowers of red color – 7.37, rose – 9.73 and white – 0.70 mg C3G 100 g^{-1} FW.

The highest content of total polyphenols was noted for *Dianthus chinensis* L. 'Chianti' flowers (12.26 mg GAE g^{-1} FW) and it was higher than determined by Chen *et al.* (2018) for *Dianthus caryophyllus* (Table 5). *D. chinensis* L. 'Chianti' flowers were also characterized by the highest antioxidant activity assessed in the FRAP test (14.22 mg TE g^{-1} FW). The highest antioxidant activity in the DPPH and ABTS test was determined for *Monarda didyma* L. flowers (respectively: 7.44 and 18.39 mg TE g^{-1} FW).

Table 3. Content of chlorophylls (μg g^{-1} FW) in selected edible flower species

Species and cultivar name	Total chlorophylls	Chlorophyll a	Chlorophyll b
Mimulus × *hybridus* L. 'Magic Yellow'	29.08±0.45 c	11.86±0.40 c	13.55±0.04 c
Mimulus × *hybridus* L. 'Magic Red'	34.32±1.71 c	14.66±0.79 c	16.44±0.80 c
Hemerocallis × *hybrida* Hort.	215.19±4.05 b	43.98±2.06 bc	154.32±3.22 b
Antirrhinum majus L. 'Cavalier'	79.99±2.04 c	35.29±2.49 bc	33.88±2.14 c
Dianthus chinensis L. 'Chianti'	369.78±14.68 a	86.17±6.97 b	257.09±5.98 a
Monarda didyma L.	461.67±18.56 a	312.74±9.33 a	107.17±2.54 b
$LSD_{\alpha = 0.05}$	125.100	68.099	58.834

Table 4. Content of L-ascorbic acid, total carotenoids and total anthocyanins in selected edible flower species

Species and cultivar name	L-ascorbic acid (mg 100g^{-1} FW)	Total carotenoids (μg g^{-1} FW)	Total anthocyanins (mg C3G 100g^{-1} FW)
Mimulus × *hybridus* L. 'Magic Yellow'	48.41±3.08 c	473.42±17.31 a	15.71±0.09 cd
Mimulus × *hybridus* L. 'Magic Red'	41.40±2.55 d	529.68±22.67 a	30.33±0.11 c
Hemerocallis × *hybrida* Hort.	75.98±2.03 b	227.11±6.98 bc	2.77±0.03 d
Antirrhinum majus L. 'Cavalier'	39.79±0.86 d	64.03±4.64 d	12.17±0.03 cd
Dianthus chinensis L. 'Chianti'	89.78±0.08 a	261.59±5.42 b	443.47±0.97 a
Monarda didyma L.	33.38±3.63 e	167.20±4.42 c	204.42±0.81 b
$LSD_{\alpha = 0.05}$	6.737	90.944	24.835

Table 5. Antioxidant activity of selected edible flower species

Species and cultivar name	Total polyphenols (mg GAE g^{-1} FW)	Antioxidant activity (mg TE g^{-1} FW)		
		DPPH	ABTS	FRAP
Mimulus × *hybridus* L. 'Magic Yellow'	2.21±0.18 d	2.24±0.43 c	7.49±0.60 f	2.59±0.16 e
Mimulus × *hybridus* L. 'Magic Red'	4.33±0.19 c	3.24±0.38 b	11.08±0.82 c	6.28±0.15 c
Hemerocallis × *hybrida* Hort.	2.06±0.02 d	3.19±0.45 b	9.49±0.69 e	4.93±0.17 d
Antirrhinum majus L. 'Cavalier'	2.66±0.02 d	1.68±0.23 d	9.98±0.28 d	2.54±0.24 e
Dianthus chinensis L. 'Chianti'	12.26±1.17 a	3.18±0.52 b	15.01±1.75 b	14.22±0.19 a
Monarda didyma L.	10.57±0.88 b	7.44±0.53 a	18.39±2.61 a	8.14±0.07 b
$LSD_{\alpha = 0.05}$	0.876	0.381	0.348	0.650

Rop *et al.* (2012) determined total phenolic content for *Antirrhinum majus* L. flowers and it was similar to our result for this species – 3.49 g GA kg^{-1} FW. Li *et al.* (2014) compared in their study 51 species of edible flowers. The highest amounts of total phenolic were noted for: *Rosa hybrida* (35.84 mg GAE g^{-1} FW), *Limonium sinuatum* (34.17 mg GAE g^{-1} FW), *Jatropha integerrima* (17.22 mg GAE g^{-1} FW), *Pelargonium hortorum* (25.68 mg GAE g^{-1} FW) and *Osmanthus. fragrans* (16.00 mg GAE g^{-1} FW). A high polyphenol concentration was also noted by Kucekova *et al.* (2011) and Moravčíková *et al.* (2012) in *Allium schoenoprasum, Rumex acetosa, Tragopogon pratensis* and *Trifolium repens* flowers. Petrova *et al.* (2016) examined the antioxidant activity of five edible flowers, where one of the extracting agent was 80% methanol. The highest total phenolic content and antioxidant activity evaluated in the FRAP test were obtained for the flowers of *Helianthus tuberosus* L. (respectively: 15.20 mg GAE g^{-1} FW, 107.5 mM TE g^{-1} FW) and in DPPH test – *Geranium macrorrhizum* L. (156.8 mM TE g^{-1} FW). Chen *et al.* (2018) were studied 30 flower species and among them the highest total polyphenol content and antioxidant activity was determined in the flowers of *Rosa rugosa* Thunb., what shows us again that edible flowers are very good sources of bioactive compounds which may be used in food and pharmaceutical industries.

Conclusions

Monarda didyma L. flowers were found to have the highest nutritional value in comparison with the other edible flower species. They contained one of the highest amounts of dry matter, total chlorophylls, and the highest content of total ash, crude fibre, total protein, chlorophyll a, and moreover they were characterized by the highest titratable acidity and antioxidant activity in the DPPH and ABTS tests. Flowers of *Dianthus chinensis* L. 'Chianti' had the highest content of L-ascorbic acid, total anthocyanins and total polyphenols; therefore, they can be used for the coloring of sugar, syrups and various potions. Moreover, they contained high amounts of dry matter, reducing sugars, total chlorophylls and chlorophyll b. The highest total soluble sugars content and sugar/acid ratio, important characteristics from the consumer point of view, were noted for *Hemerocallis* × *hybrida* Hort. and *Antirrhinum majus* L.

'Cavalier' flowers. Flowers of *Mimulus* × *hybridus* L. cultivars were found to be the best source of total carotenoids in comparison with the other edible flower species.

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