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Research Article

Relationship between Major Mineral Nutrient Elements Contents and Flower Colors of Herbaceous Peony (Paeonia Lactiflora Pall.)

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Abstract: Herbaceous peony (*Paeonia lactiflora* Pall.) is a famous ornamental plant with bright flowers and lush leaves. The flower petal can be used as a fragrant food additive. Understanding the mineral nutrient contents in *P. lactiflora* is necessary for guiding its cultivation practices as well as its use as a food additive. In this study, we investigated the mineral contents including Calcium (Ca), Potassium (K), Magnesium (Mg), Copper (Cu), iron (Fe) and Zinc (Zn) in petals and leaves of 20 selected herbaceous peony cultivars in four groups according to their flower colors and the relationship between major mineral nutrient elements contents and flower colors was assessed. In petals, the contents of minerals were in this order K>Ca>Mg>Fe>Zn>Cu; while in leaves were: Ca>K>Mg>Fe>Zn>Cu. Major element contents in petals and leaves among 4 cultivar groups were different at statistically significant levels. Petals in red or purple have higher amount of most major minerals than those in white or pink colors. The wide range of mineral element contents among cultivars is attributed to genotypic variations. The correlations of major mineral elements in the petals and leaves of herbaceous peony cultivars indicate that mineral ions compete for the same absorption sites. The results provided some scientific support for petal nutrition of herbaceous peony and selecting herbaceous peony flowers with dark colors for edible is feasible.

Keywords: Herbaceous peony, mineral element, petal nutrition

INTRODUCTION

Herbaceous peony (*Paeonia lactiflora* Pall.), a famous ornamental plant with bright flowers and lush leaves, is widely cultivated in the world (Li, 1999; Shen *et al*., 2012). Herbaceous peony has been cultivated for more than 2,000 years in China and used for landscaping, pot culture and cut flowers (Cheng *et al*., 2009; Zhao *et al*., 2012). Herbaceous peony roots and leaves contain rich amounts of bioactive compounds such as paeoniflorin (Lee *et al*., 2009), oleanolic and ursolic acids (Zhou *et al*., 2011) which make the plant a natural medicinal source as well (Chen *et al*., 2009; Zhao *et al*., 2009; Jian *et al*., 2011). Furthermore, herbaceous peony petals are edible which have a good nutritional value without any detectable toxicity (Zhang and Sun, 1998; Wang *et al*., 2009; Yu, 2011).

To rationally design cultivation medium and fertilizers, the mineral elements uptaken by herbaceous peonies from nutrient solution and/or substrate were studied (Li, 2010; Lu and Yu, 2011). The uptake of Cacium (Ca) was studied for its effect on extending the vase life of P. lactiflora cut flowers (Hui *et al*., 2009; Tang *et al*., 2009; Yu *et al*., 2010) and for its effects on the inflorescence stem properties and leaf photosynthetic status (Li *et al*., 2012 a, b). On the other hand, knowledge of the microelements such as Zn, Cu, Fe and Mn, in the edible petals is important to promote its use as a food additive (AL-Majthoub and Salman, 2012; Lakhe and Mangaonkar, 2012; Kelode and Mandlik, 2012; Jamuna *et al*., 2012; Lonnerdal, 2003; Rop *et al*., 2012; Hu *et al*., 2008; Ji *et al*., 2012). However, studies on of the amount of mineral elements in different P. lactiflora varieties are not available yet.

Anthocyanins and other flavonoids pigments are derivatives of plant secondary metabolites, which largely contribute to rich colors of stems, leaves, flowers and fruits (Kong *et al*., 2003; Pawel *et al*., 2009). Mineral elements are one of the main factors for anthocyanins synthesis (Zheng, 2000; Yoshida *et al*., 2006). Previous studies suggested a positive correlation between anthocyanins contents and mineral elements contents (e.g., Ca, Mg, Cu, Zn) (Li, 2005; Li *et al*., 2010). The relationship between herbaceous peony petal color and mineral elements contents was not reported yet.

In this study, major mineral elements contents in herbaceous peony petals and leaves are investigated in different cultivar groups and the relationship between major mineral nutrient elements contents and flower colors was assessed. One of the aim in the study is to provide useful data for its use as an edible flower, ant the other is, provide a scientific basis for the diagnosis

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Fig. 1: Herbaceous peony cultivars in different types. The group of herbaceous peony is indicated as the petal color of cultivar: P: Pink peony cultivars, PU: Purple peony cultivars, R: Red peony cultivars, W: White peony cultivars. Color of all cultivars was accessed by Royal Horticultural Society Colour Chart. Group W cultivars from W-1 to W-5 as: 'Qiao Ling', 'Xue Feng', 'Yangfei Chuyu', 'Yulou Hongxing', 'Yurun Qihua'; Group P: 'Fen Yulou', 'Taohua Feixue', 'Yingxiong Hua', 'Zhong Shengfen', 'Zhusha Pan'; Group R: 'Da Fugui', 'Hong Feng', 'Rongsheng Hong', 'Zifeng Chaoyang', 'Ziyan Feishuang'; and Group PU: 'Heihai Botao', 'Molou Jinhui', 'Zilian Wangyue', 'Ziling Cangjin', 'Ziyan Zhenghui'

of nutritional condition for balanced fertilization during herbaceous peony cultivation.

MATERIALS AND METHODS

Plant materials and analysis: Herbaceous peony samples were collected from the peony nursery in Yangzhou University, Jiangsu Province, China (32°30′N, 119°25′E). More than 120 different herbaceous peony cultivars have been maintained in this nursery since 2008.

Twenty herbaceous peony cultivars classified in four groups according to their flower colors were sampled in the same field in April 2012 (Fig. 1): Group W as white petal cultivars ('Qiao Ling,' 'Xue Feng,' 'Yangfei Chuyu,' 'Yulou Hongxing,' 'Yurun Qihua'), Group P as pink petal cultivars ('Fen Yulou,' 'Taohua Feixue,' 'Yingxiong Hua,' 'Zhong Shengfen,' 'Zhusha Pan'), Group R as red petal cultivars ('Da Fugui,' 'Hong Feng,' 'Rongsheng Hong,' 'Zifeng Chaoyang,' 'Ziyan Feishuang'), Group PU as purple petal cultivars ('Heihai Botao,' 'Molou Jinhui,' 'Zilian Wangyue,' 'Ziling Cangjin,' 'Ziyan Zhenghui').

For each cultivar, three different peony specimens were selected to sample the petals and leaves. The petals were taken in full bloom and the leaves were taken from the upper part of the inflorescence stems.

The petals and leaves at the same growth or developmental stage were washed with distilled water, fixed at 105°C for 15 min and dried at 70°C until constant weight. The samples were subsequently mixed and ground through 100 mesh. Precisely 0.2 g of each sample was weighted and then placed into test tubes. Then, 5 mL of nitric acid, 3 mL of ultrapure water and two drops of hydrogen peroxide were added sequentially into the test tubes. The tubes were heated in the microwave digestion system (MARS 5, CEM, USA). Mineral concentrations were determined by atomic absorption spectrophotometer (Solar S4+Graphite Furnace System 97, Thermo Elemental, USA).

Statistical analysis: SPSS 16.0 was used for statistical analysis. Differences among the four Groups of herbaceous peony cultivars were analyzed using a general linear model with the Group of peony as a factor. The mean concentrations in each Group were compared using a post hoc Tukey's test at the 95% confidence level and one-way ANOVA.

RESULTS AND ANALYSIS

In petals, the mineral elements contents in the selected 20 cultivars were listed in Table 1 and 2. The contents of minerals were in this order: K>Ca>Mg>Fe>Zn>Cu. For all the mineral elements tested, the contents were positively associated with the darkness of petal colors and cultivars with light petal colors have the lowest elements contents. The Ca contents ranged from 2.56 to 5.16 mg/g. 'Zifeng Chaoyang', belonging to Group R, has the highest

Table 1: Mean major mineral element concentrations in petals of each herbaceous peony cultivar

Group	Cultivar name	Ca (mg/g)	K (mg/g)	Mg (mg/g)	Cu (mg/kg)	Fe (mg/kg)	Zn (mg/kg)
W	'Qiao Ling'	3.08±0.09	10.71±0.20	1.59±0.07	8.470±0.18	68.530±0.18	29.36±0.14
W	'Xue Feng'	4.08±0.06	13.49±0.11	1.61±0.06	9.010±0.09	66.030±0.12	25.59±0.08
W	'Yangfei Chuyu'	2.66±0.10	11.18±0.11	1.37±0.09	9.460±0.08	63.040±0.08	24.29±0.10
W	'Yulou Hongxing'	3.27±0.10	10.95±0.13	1.67±0.13	6.650±0.46	70.960±0.68	27.79±0.29
W	'Yurun Qihua'	3.72±0.11	11.63±0.13	1.50±0.03	8.860±0.10	67.420±0.18	30.50±0.18
P	'Fen Yulou'	3.06±0.10	11.32±0.09	1.46±0.11	6.930±0.22	75.660±0.40	29.54±0.17
P	'Taohua Feixue'	3.61±0.11	12.76±0.11	1.39±0.06	8.320±0.12	78.360±0.14	27.52±0.15
P	'Yingxiong Hua'	4.19±0.04	11.83±0.05	1.48±0.04	8.550±0.18	80.410±1.15	30.70±0.44
P	'Zhong Sheng Fen'	3.38±0.10	12.91±0.11	1.48±0.10	6.570±0.12	73.560±0.11	27.09±0.11
P	'Zhusha Pan'	3.87±0.09	11.89±0.11	1.48±0.10	7.610±0.10	84.030±0.85	28.43±0.21
R	'Da Fugui'	3.76±0.11	12.37±0.08	1.72±0.04	10.15±0.07	112.66±0.22	28.56±0.04
R	'Hong Feng'	4.06±0.07	13.99±0.13	1.53±0.09	11.76±0.16	104.82±0.10	29.02±0.09
R	'Rongsheng Hong'	3.67±0.14	12.91±0.14	1.67±0.10	11.54±0.13	109.12±0.20	30.58±0.22
R	'Zifeng Chaoyang'	4.97±0.20	12.76±0.11	1.66±0.07	13.50±0.09	96.060±0.13	29.85±0.09
R	'Ziyan Feishuang'	4.20±0.12	13.68±0.05	1.56±0.06	10.70±0.09	105.89±0.08	29.40±0.11
PU	'Heihai Botao'	4.22±0.08	13.43±0.05	1.72±0.12	8.280±0.10	133.33±0.11	29.04±0.08
PU	'Molou Jinhui'	4.05±0.04	11.34±0.11	1.75±0.07	8.830±0.09	111.76±0.22	33.87±0.11
PU	'Zilian Wangyue'	4.40±0.11	14.35±0.03	1.76±0.07	7.800±0.12	119.26±0.11	36.20±0.09
PU	'Ziling Cangjin'	3.59±0.10	12.00±0.12	1.72±0.11	7.500±0.09	118.00±0.12	31.06±0.12
PU	'Ziyan Zhenghui'	4.83±0.10	15.49±0.13	1.84±0.06	7.000±0.10	121.73±0.23	33.21±0.11

The group of herbaceous peony is indicated as petal color of cultivar; W: White peony cultivars; P: Pink peony cultivars; R: Red peony cultivars; PU: Purple peony cultivars

Table 2: Variations in the concentrations of major minerals in the petals of different herbaceous peony cultivars

Elements	Mean ± standard deviation	Coefficient of variation (%)	Range
Ca (mg/g)	3.830±0.580	15.04	2.560-5.1600
K (mg/g)	12.55±1.240	9.890	10.52-15.620
Mg (mg/g)	1.600±0.150	9.150	1.290-1.8900
Cu (mg/kg)	8.870±1.830	20.59	6.120-13.590
Fe (mg/kg)	93.03±22.07	23.73	62.97-133.43
Zn (mg/kg)	29.58±2.680	9.080	24.19-36.290

content (4.97 mg/g). The K and Mg contents ranged from 10.52 to 15.62, 1.29 to 1.89 mg/g, respectively. 'Ziyan Zhenghui', belonging to Group PU, also has the highest K (15.49 mg/g) and Mg (1.84 mg/g) contents. The Cu contents ranged from 6.12 to 13.59 mg/kg, the highest one was 'Zifeng Chaoyang' (13.50 mg/kg), belonging to Group R. The Fe and Zn contents ranged from 62.97 to 133.43, 24.19 to 36.29 mg/kg, respectively. The highest Fe and Zn contents cultivars were 'Heihai Botao' (133.33 mg/kg) and 'Zilian Wangyue' (36.20 mg/kg), respectively, both belonging to Group PU. As for the lowest mineral contents cultivar, 'Yangfei Chuyu', belonging to Group W, has the lowest Ca (2.66 mg/g), Mg (1.37 mg/g), Fe (63.04 mg/kg) as well as Zn contents (24.29 mg/kg). 'Qiao Ling', belonging to Group W, has the lowest K contents (10.71 mg/g) and 'Zhongshengfen', belonging to Group P, has the lowest Cu contents (6.57 mg/kg).

In leaves, the mineral elements concentrations in the selected 20 cultivars were listed in Table 3 and 4. The contents of minerals were in the order as follows: Ca>K>Mg>Fe>Zn>Cu. Ca, Cu, Fe as well as Zn contents were positively associated with the darkness of petal colors. The Ca contents ranged from 14.07 to 20.40 mg/g and the highest cultivar was 'Ziling Cangjin' (20.20 mg/g), belonging to Group PU. The Cu, Fe along with Zn contents ranged from 8.20 to 10.54, 323.00 to 421.97 and 51.02 to 68.56 mg/kg, respectively. 'Zilian Wangyue' has the highest Cu (10.44 mg/kg), Fe (415.68 mg/kg) and Zn (68.37 mg/kg) contents. 'Yangfei Chuyu' has the lowest Ca (14.23 mg/g) along with Zn (51.38 mg/kg) contents. 'Qiao Ling' has the lowest Cu (8.30 mg/kg) contents and 'Taohua Feixue', belonging to Group P, has the lowest Fe (326.70 mg/kg) contents. K and Mg contents were negatively associated with the darkness of petal colors. The K contents ranged from 7.30 to 11.19 mg/g and the highest along with the lowest one was 'Yangfei Chuyu'(11.05 mg/g), 'Ziling Cangjin' (7.51 mg/g), respectively. The Mg contents ranged from 3.82 to 5.02 mg/g and the highest along with the lowest one was 'Yurun Qihua'(4.87 mg/g), belonging to Group W, 'Heihai Botao'(3.96 mg/g), respectively.

Both the soil and climatic environment were similar for all the tested cultivars. Thus, the wide range of minerals contents among cultivars is possibly caused by genotypic variation. Our results also agree with the findings on bamboo (Collin *et al*., 2012), bougainvillea (Xu *et al*., 2011), chrysanthemum (Jin *et al*., 2010) and wheat (Zhang *et al*., 2007).

Correlation analysis between major mineral elements in petals and leaves: The correlation coefficients of major mineral elements in petals and leaves are shown in Table 5 and 6, respectively. In the petals, significantly positive

Table 3: Mean major mineral element concentrations in leaves of each herbaceous peony cultivar

Group	Cultivar name	Ca (mg/g)	K (mg/g)	Mg (mg/g)	Cu (mg/kg)	Fe (mg/kg)	Zn (mg/kg)
W	'Qiao Ling'	16.19±0.13	9.82±0.18	4.71±0.10	8.30±0.10	328.06±2.21	58.57±0.22
W	'Xue Feng'	16.49±0.16	10.40±0.13	4.67±0.14	8.71±0.19	354.84±4.69	58.81±0.22
W	'Yangfei Chuyu'	14.23±0.15	11.05±0.15	4.67±0.15	8.58±0.18	345.26±2.83	51.38±0.44
W	'Yulou Hongxing'	16.05±0.09	10.37±0.16	4.11±0.13	8.44±0.12	349.36±4.29	59.55±0.36
W	'Yurun Qihua'	16.37±0.15	9.440±0.12	4.87±0.16	9.00±0.14	366.83±4.08	59.34±0.23
P	'Fen Yulou'	16.85±0.15	9.770±0.10	4.50±0.13	8.58±0.10	367.85±3.42	59.26±0.22
P	'Taohua Feixue'	17.37±0.09	9.570±0.21	4.35±0.14	8.72±0.09	326.70±3.57	59.25±0.21
P	'Yingxiong Hua'	17.43±0.24	9.510±0.15	4.28±0.10	8.46±0.15	376.44±3.64	58.09±0.14
P	'Zhong Sheng Fen'	17.53±0.25	9.360±0.11	4.12±0.09	8.96±0.14	374.48±5.88	57.62±0.26
P	'Zhusha Pan'	17.47±0.20	9.880±0.13	4.01±0.14	9.05±0.13	347.82±4.57	57.69±0.23
R	'Da Fugui'	18.54±0.14	9.230±0.12	4.05±0.11	9.55±0.16	355.49±5.73	67.15±0.48
R	'Hong Feng'	18.85±0.10	8.890±0.10	4.27±0.10	9.90±0.16	361.28±5.70	62.22±0.22
R	'Rongsheng Hong'	18.38±0.14	8.810±0.11	4.11±0.11	10.33±0.16	409.57±8.30	63.55±0.33
R	'Zifeng Chaoyang'	19.13±0.10	9.170±0.12	4.33±0.15	9.55±0.25	363.96±6.46	64.16±0.26
R	'Ziyan Feishuang'	19.05±0.11	9.060±0.11	4.21±0.07	10.17±0.11	349.64±8.42	61.47±0.20
PU	'Heihai Botao'	19.96±0.10	7.820±0.13	3.96±0.14	9.85±0.13	384.80±5.79	63.94±0.17
PU	'Molou Jinhui'	19.44±0.14	8.060±0.10	4.15±0.07	9.16±0.13	391.75±5.72	66.97±0.18
PU	'Zilian Wangyue'	20.19±0.20	8.460±0.22	4.14±0.13	10.44±0.11	415.68±6.29	68.37±0.18
PU	'Ziling Cangjin'	20.20±0.13	7.510±0.22	4.35±0.16	9.67±0.21	409.78±4.40	63.50±0.23
PU	'Ziyan Zhenghui'	19.82±0.12	8.29±0.14	4.09±0.09	10.34±0.19	398.74±4.66	66.32±0.23

The group of herbaceous peony is indicated as petal color of cultivar; W: White peony cultivars; P: Pink peony cultivars; R: Red peony cultivars; PU: Purple peony cultivars

Table 4: Variations in the concentrations of major minerals in the leaves of different herbaceous peony cultivars

Elements	Mean ± standard deviation	Coefficient of variation (%)	Range
Ca (mg/g)	17.980±1.620	9.00	14.07-20.400
K (mg·g)	9.2200±0.890	9.69	7.300-11.190
Mg (mg·g)	4.3000±0.270	6.37	3.820-5.0200
Cu (mg·kg)	9.2900±0.710	7.63	8.200-10.540
Fe (mg·kg)	369.24±26.12	7.07	323.0-421.97
Zn (mg·kg)	61.36±4.1100	6.70	51.02-68.560

Table 5: Correlations among the concentrations of six minerals in the petals of herbaceous peony cultivars

	Ca	K	Mg	Cu	Fe	Zn
Ca	1.00					
K	0.69**	1.00				
Mg	0.48**	0.35**	1.00			
Cu	0.34**	0.15	0.03	1.00		
Fe	0.59**	0.58**	0.66**	0.17	1.00	
Zn	0.53**	0.31*	0.57**	-0.07	0.62**	1.00

*: Significant at 0.05 probability level; **: Significant at 0.01 probability level

Table 6: Correlations among the concentrations of six minerals in the leaves of herbaceous peony cultivars

	Ca	K	Mg	Cu	Fe	Zn
Ca	1.00					
K	-0.92**	1.00				
Mg	-0.58**	0.44**	1.00			
Cu	0.79**	-0.69**	-0.49**	1.00		
Fe	0.66**	-0.72**	-0.34**	0.63**	1.00	
Zn	0.86**	-0.78**	-0.50**	0.71**	0.60**	1.00

correlations were observed between the contents of Ca and K (r = 0.69**) and between Ca and Mg (r = 0.48**) and between K and Mg (r = 0.35**). In the leaves, significantly positive correlations were observed between the contents of K and Mg (r = 0.44**), whereas significantly negative correlations were observed between Ca and K (r = -0.92**) and between Ca and Mg (r = -0.58**). In the petals, a significantly positive correlation was observed between the contents of Fe and Zn (r = 0.63**), whereas no close correlations were found between Cu content and Fe (r = 0.17) and between Cu and Zn contents (r = -0.07). However, in the leaves, a significantly positive correlation was found between the content of Cu and Fe (r = 0.63**), between Cu and Zn (r = 0.71**) and between Fe and Zn (r = 0.60**).

In the petals, a significantly positive correlation was observed between the contents of Ca and Cu (r = 0.34**), between Ca and Fe (r = 0.59**), between Ca and Zn (r = 0.53**), between K and Fe (r = 0.58**), between Mg and Fe (r = 0.66**) and between Mg and Zn (r = 0.57**), whereas no close correlations were found between K and Cu (r = 0.15) and between Mg and Cu (r = 0.03). In the leaves, a significantly positive correlation was found between the contents of Ca and Cu (r = 0.79**), between Ca and Fe (r = 0.66**) and between Ca and Zn (r = 0.86**), however, a significantly negative correlation was found between the contents of K and Cu (r = -0.69**), between K and Fe (r = -0.72**), between K and Zn (r = -0.78**) and between Mg and Cu (r = -0.49**), between Mg and Fe (r = -0.34**) and between Mg and Zn (r = -0.50**).

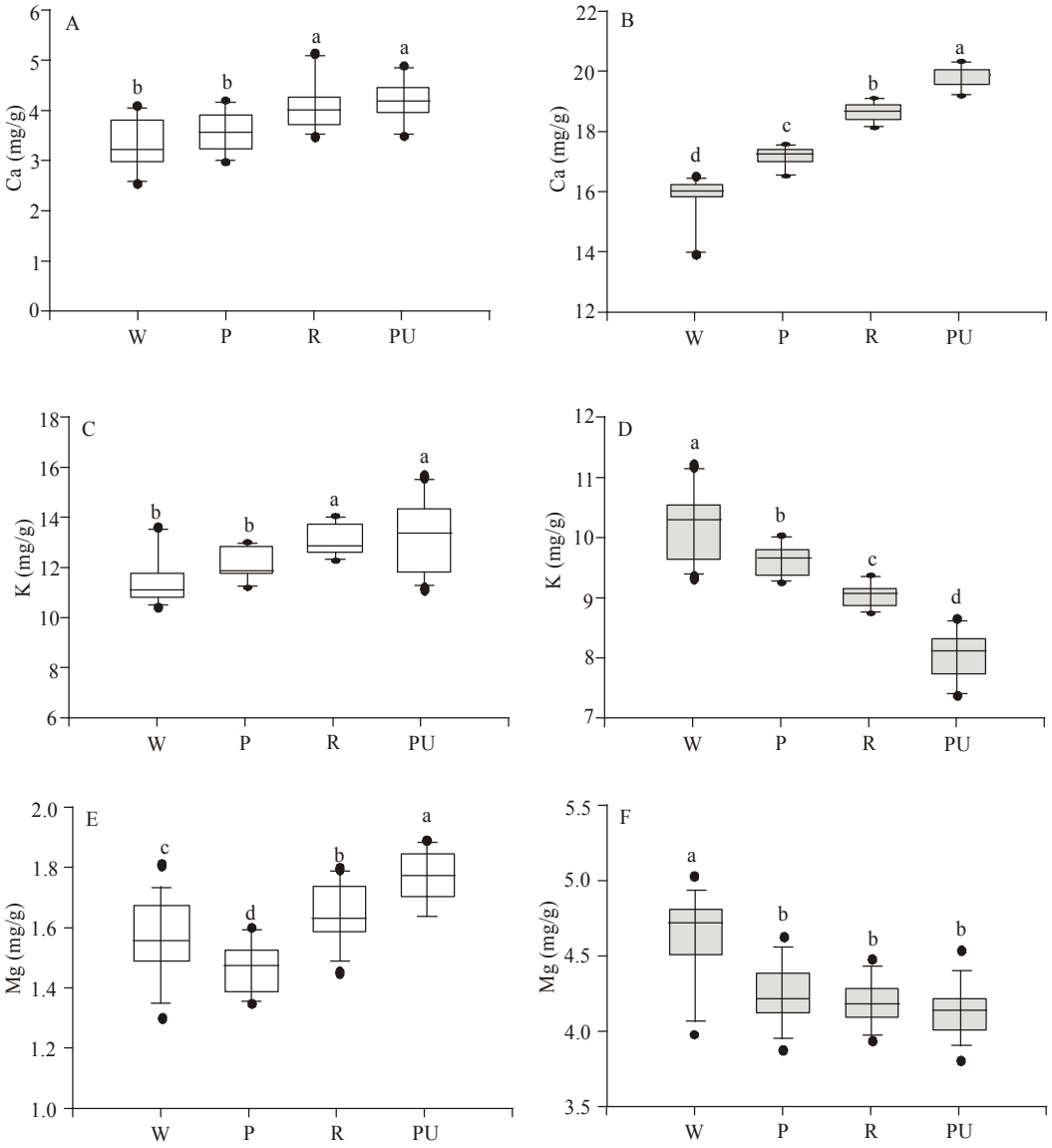

Fig. 2: Comparison of macroelements in the petals and leaves of different groups of herbaceous peony cultivars; A: Ca in the petals; B: Ca in the leaves; C: K in the petals; D: K in the leaves; E: Mg in the petals; F: Mg in the leaves. Different letters above the box indicate significant difference at P = 0.05 between different types of herbaceous peonies

Different correlations between major mineral elements in the petals and leaves of herbaceous peony cultivars indicate that mineral ions compete for the same absorption sites, which is related to the presence of collaborative absorption or transit (Hegelund *et al*., 2012).

Difference of major mineral contents between herbaceous peony cultivar groups:

Difference of macro elements contents between cultivar groups: The Ca concentrations in the petals and in leaves gradually increased as the petal color darkened (Fig. 2). The concentration of Group W in petals was 3.36 mg/g, with deepening petal color; Group PU was 4.42 mg/g. No significant differences were found between Group W and Group P and between Group R and Group PU, whereas a significant difference was observed between Group P and Group R. In the leaves, the Ca concentrations in different cultivar Groups ranged from 15.87 to 19.92 mg/g and significant differences were found between the four Groups of cultivars.

The K concentrations in the petals gradually increased with deepening petal color, whereas the K concentrations gradually decreased in the leaves. The contents ranged from 11.59 mg/g (Group W) to 13.32 mg/g (Group PU) in the petals and 10.22 mg/g (Group W) to 8.03 mg/g (Group PU) in the leaves. In the petals, no significant differences were found

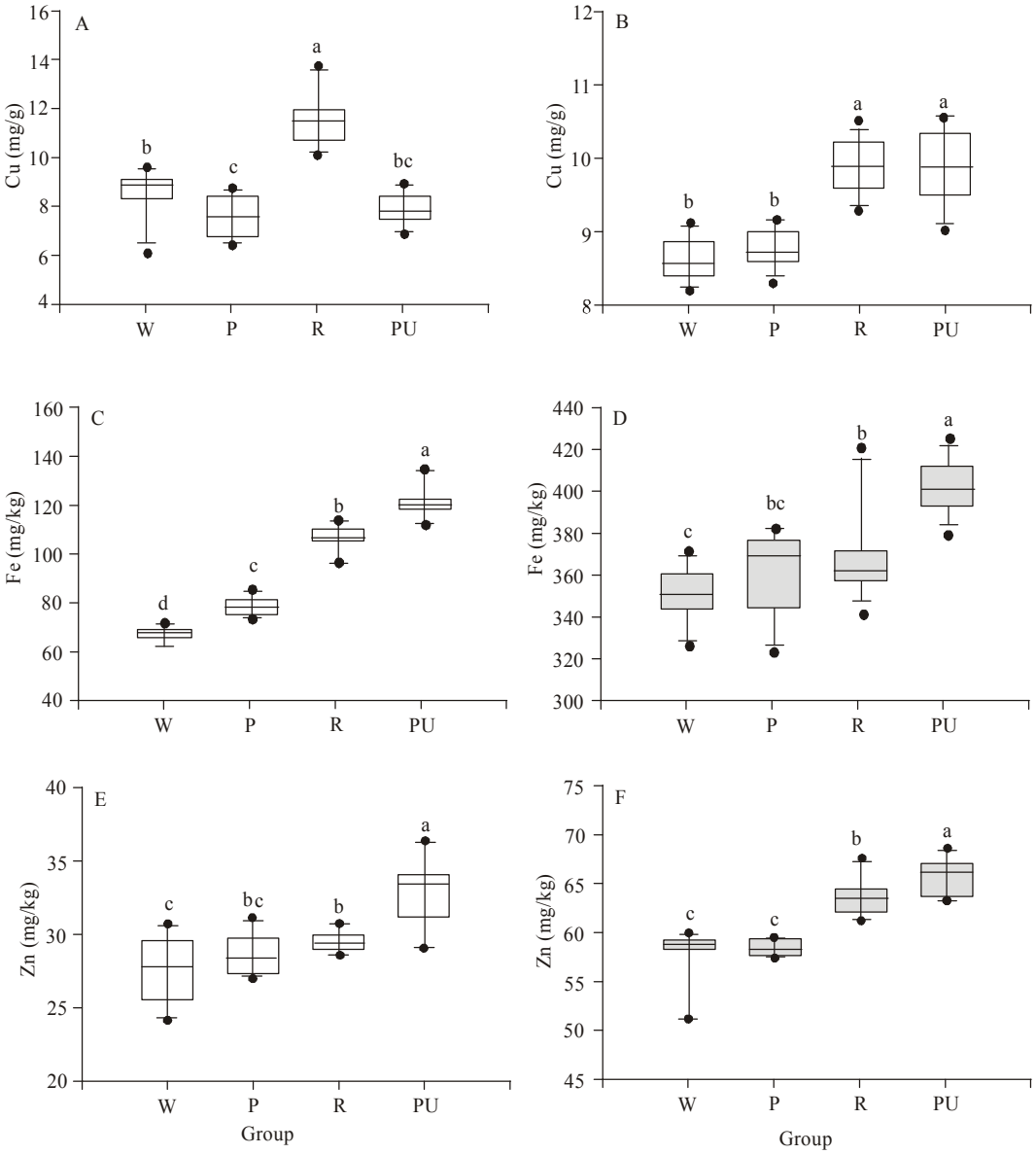

Fig. 3: Comparison of microelements in the petals and the leaves of different groups of herbaceous peony cultivars; A: Cu in the petals; B: Cu in the leaves; C: Fe in the petals; D: Fe in the leaves; E: Zn in the petals; F: Zn in the leaves. Different letters above the box indicate a significant difference at P = 0.05 between different types of herbaceous peonies

between Group W and Group P and between Group R and Group PU, whereas a significant difference was found between Group P and Group R.

Difference of microelements contents between cultivar groups: The Cu concentrations in the petals were not correlated with the deepening petal color. The highest concentration was Group R (11.53 mg/kg) and the lowest concentration was Group P (7.60 mg/kg) (Fig. 3). Significant differences were found between Group W and Group P, between Group W and Group R and between Group P and Group R. In the leaves, the Cu concentrations gradually increased from Group W (8.60 mg/kg) to Group P (9.90 mg/kg) and the content of Group PU (9.89 mg/kg) was slightly lower than that of Group P. A significant difference was found between Group P and Group R; however, no significant differences were observed between Group W and Group P, as well as between Group R and PU.

The Mg concentrations in the petals showed a slightly different trend from the other two microelements. The lowest concentration was found in Group P (1.46 mg/g), not Group W (1.55 mg/g), even though the highest concentration was in Group PU (1.76 mg/g).

The Fe concentrations in the petals significantly increased along with the deepening of petal color. The content of Group PU was 120.81 mg/kg, which was

approximately twice that of Group W (67.20 mg/kg). In the leaves, the contents gradually increased with deepening petal color, except in Group R. A significant difference was found between Group W (348.87 mg/kg) and Group R (367.99 mg/kg) and between Group W and Group PU (400.15 mg/kg), whereas no significant differences were found between Group W and Group P (358.66 mg/kg) and between Group P and Group R.

The Zn concentrations gradually increased from Group W (27.51 mg/kg) to Group PU (32.68 mg/kg) and a significant difference was found between Group W and Group R (29.48 mg/kg) and between Group W and Group PU. However, no significant differences were found between Group W and Group P (28.66 mg/kg) and between Group P and Group R. In the leaves, the contents gradually increased with deepening petal color, except in Group P (58.38 mg/kg), which was slightly decreased than that of Group W (57.53 mg/kg) and Group PU (65.82 mg/kg) has the highest content. Significant differences were found between Group W and Group R, between Group W and Group PU and between Group R and Group PU, but no significant difference was found between Group W and Group P.

CONCLUSION

The concentrations of microelements such as Ca, K and Mg and those of microelements such as Fe, Cu and Zn in the petals and the leaves of herbaceous peony cultivars were determined. The concentrations of major minerals were different among herbaceous peony cultivars and parts showed significant differences. The distributions between the different parts of herbaceous peony cultivars in the same field were uneven. Herbaceous peony petals were rich in K and less in Ca and Mg, whereas the leaves were rich in Ca and Mg. Fe and Zn were rich in both the petals along with leaves and Cu were in less. In summary, the results showed the range and variability of major minerals between cultivars; the association of petal color and mineral nutrients content are drawn which indicated some genotypic characteristics are responsible for mineral accumulation.

Our data show that the petals of herbaceous peony cultivars with dark colors such as red and purple are rich in most major mineral elements. The correlations were almost positive among major mineral elements in herbaceous peony petals and leaves, which indicate that selecting herbaceous peony flowers with dark colors for edible is feasible.

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