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THE CONTENT OF ESSENTIAL ELEMENTS IN THE FLOWERS AND FRUITS OF CHAENOMELES (Chaenomeles Lindl.)

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ABSTRACT
Chaenomeles sp. (*C. cathayensis*, *C. japonica*, *C. spesiosa* and *C. x superba*) are characterized by rich chemical composition of all plant parts and the wide variability of the accumulation of separate components in different species and cultivars. For the expansion of ideas about the chaenomeles content nutritional value of 7 essential macro- and microelements in the flowers and fruit of 8 cultivars from the Nikita Botanical Gardens collection have been studied. Analysis of plant samples was carried out by dry ashing with subsequent determination of mostelements on the atomic absorption spectrophotometer. Ca and Mg were determined by complex metric method. It was revealed that essential elements were accumulated in the flowers and fruits in different quantities. The maximum amount of K, Fe, Mg, Zn, Cu and Mn is contained in the flowers. The largest amount of Ca was detected in fruits, whereas Zn, Mn and Cu were most presented in seeds. The studied cultivars differ significantly in accumulation of essential elements. According to the studied complex components, the accession P-8-3 was allocated. Flowers were characterized by the highest content of Ca, Zn, Mn, Cu and high content – of K; fruits were rich in K, Ca, Zn, Mn and Cu. In the jam from the chaenomeles fruit, the high content of K (2087 mg 100 g^{-}, i. e. more than 2%) was revealed. It is seven fold higher than daily rate for human. Thus, chaenomeles flowers, fruits and seeds are a valuable raw material, enriched with vital macro- and microelements.

Key words: *nutritional value, breeding, macro and microelements.*

INTRODUCTION
The chaenomeles (Chaenomeles Lindl.,fam. Rosaceae Juss.,subfam. Amygdalo-ideae Arn.,syn. Maloideae C. Weber) is a popular ornamental, but relatively rare in Europe fruit culture. The interest of researchers to it as a medicinal and food plant increases in the last decades more and more not only in the countries of South-East Asia where it originate, but also in other regions of cultivation. Thanks to the rich chemical composition, high content of ascorbic acid, phenolic compounds, pectin, fiber and other substances the chaenomeles fruits are a valuable raw material for a different of processed foods rich in biologically active substances: juice, puree,

aroma extracts, syrups, liqueurs, carbonated soft drinks, jams, candies, pectin, dietary fiber blends (Lesinska and Kraus, 1996; Rumpunen, 2002; Tarko *et al.*, 2014). Fruits, flowers and leaves of chaenomeles are also of great interest as a pharmaceutical raw material and widely used in traditional Chinese medicine. Many research works devoted to the study of medicinal properties of various parts of chaenomeles, experimental drugs which have anti-inflammatory, hepatoprotective, antibacterial and other health effects are obtained and tested (Komar-Tyomnaya and Tarachtiev, 1999; Lim, 2012; Dzhan *et al*., 2010b).
Minerals are important for human life support as proteins, fats, carbohydrates vitamins and other biologically active substances. They participate in the most important metabolic processes in the human body, are the building blocks of cells. Therefore, study of the composition of essential macro- and micronutrients of food and medicinal plants is actual. The former conducted study of the chaenomeles elemental composition revealed a significant content of potassium, iron, calcium and other essential and conditionally essential elements in the flowers, leaves and fruits (Komar-Tyomnaya *et al*., 2000; Dzhan *et al*., 2010a; Lesinska and Kraus, 1996). Chaenomeles is characterized by the wide variability of the accumulation of separate components in different taxa and different plant parts (Komar-Tyomnaya, Paliy, 2015). Therefore, a number of studies are carried out on specific varietal or breeding material distributed in research area. The aim of this study is reconnaissance analysis of the contents of 7 essential macro- and microelements in the flowers and fruits of the 8 chaenomeles genotypes from the Nikita Botanical Gardens collection for extendingideas about food and biological value of this crop.

MATERIALS AND METHODS

Plant material._The material for the study were the flowers and fruits of 8 chaenomeles selected forms of Nikita Botanical Gardens collection, originating from species *C. cathayensis* (XK-2-1), *C. japonica* (PX-3-10, PX-4-4, PX-5-15), *C. spesiosa* (P-1-2-1) and *C. x superba* (P-8-3, P-5-11, P-5-9). The analyzed sample of seeds was collected from several genotypes. All the plantsareseedlingsfromopen pollinationof the best selected formsand cultivars, the seeds of whichwere obtainedfrom differentbotanical gardens andpomologicalinstitutions.
Analysis of the plant materials. Analysis of plant samples was carried out by dry ashing (Grishina and Samoilova, 1971) with subsequent determination of most elements on the atomic absorption spectrophotometer S-115 PKS in the absorption mode (Fe, Mn, Cu and Zn) or in the emission mode (K). Ca and Mg were determined by complex metric method (Yagodin, ed., 1987). In the analysis absolutely dry plant material in an amount of 100 g was placed in a porcelain dish, slowly warmed in a muffle furnace to 500°C and was ashed for 4-6 hours until complete disappearance of residues carbon in the ash. After cooling in a desiccator, cup with ash was weighed and then the ash was moistened with several drops of distilled water. 10% hydrochloric acid solution was poured to moistened ash by drops until the termination of the boiling reaction. After that, the ash solution was

transferred from the cup through a filter in 100 ml flask. Residue on the filter was washed with distilled water several times, and the volume of solution in the flask was brought to the 100 ml. The obtained ash solution was usedfor the analysis of macro- and microelements in the plant material.

RESULTS AND DISCUSSION

The study revealed that the quantity of essential elements in different parts of plants, and in chaenomeles accessions differs significantly. In the chaenomeles flowers higher content of the vast majority of essential macro- and microelements was observed than in fruits and seeds. Their total amount is 2730. 5 mg 100 g^{-}of dry matter, which are 2. 5 times larger than in the fruits and 1. 5 times larger than in the seeds (Table 1). The maximum amount of K, Fe, Mg, Zn, Mn and Cu was found in the flowers (Fig. 1). The average amount of K in the flowers was 2180. 7 mg 100 g^{-}and exceeds its content in the fruits for 1. 6 times. The Mg content was 376. 8 mg 100 g^{-}, which is 4. 1 times higher than in the fruits. Zn and Fe had the greatest superiority in amount among microelements in the flowers. Their amounts were 3. 77 mg 100 g^{-} and 6. 05 mg 100 g^{-}, respectively, which are 4. 5 times larger in the fruits (Fig. 2). The average Cu content in the flowers was 1. 0 mg 100 g^{-}, which exceed the amount in the fruits for 4. 2 times. The amount of Mn was 0. 3 mg 100 g^{-} which on average was 2. 3 times more than in fruits.

Table 1. The average content of essential elements in different parts of *Chaenomeles* plants, mg 100 g^{-} (on dry weight basis).

Plant material	K	Ca	Mg	Fe	Zn	Cu	Mn	Σ*
Flowers	2180. 7	161. 8	376. 8	6. 05	3. 77	1. 01	0. 30	2730. 5
Fruits	1378. 6	289. 7	91. 8	1. 38	0. 83	0. 24	0. 13	1761. 3
Seeds	558. 8	268. 2	234. 9	2. 50	3. 69	1. 62	0. 46	1070. 2

* – The total content of macro- and microelements.

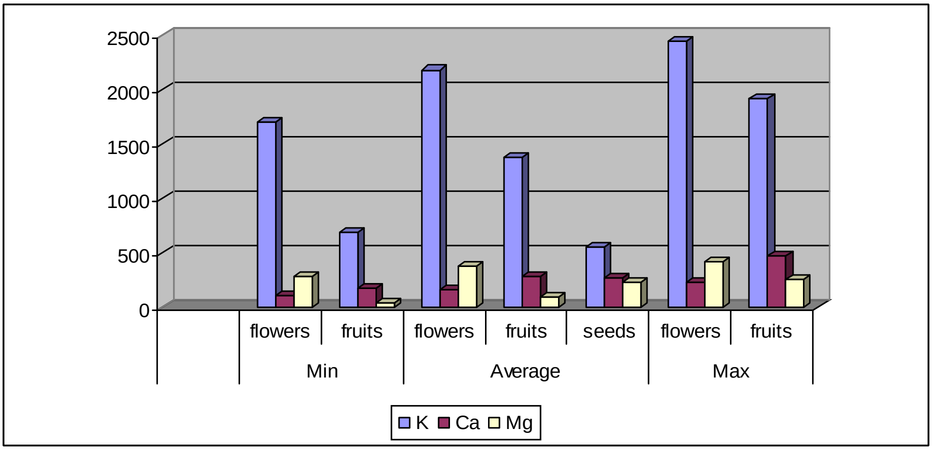

Figure 1. Content of macroelements in the flowers and fruits of Chaenomeles, mg 100 g^{-}.

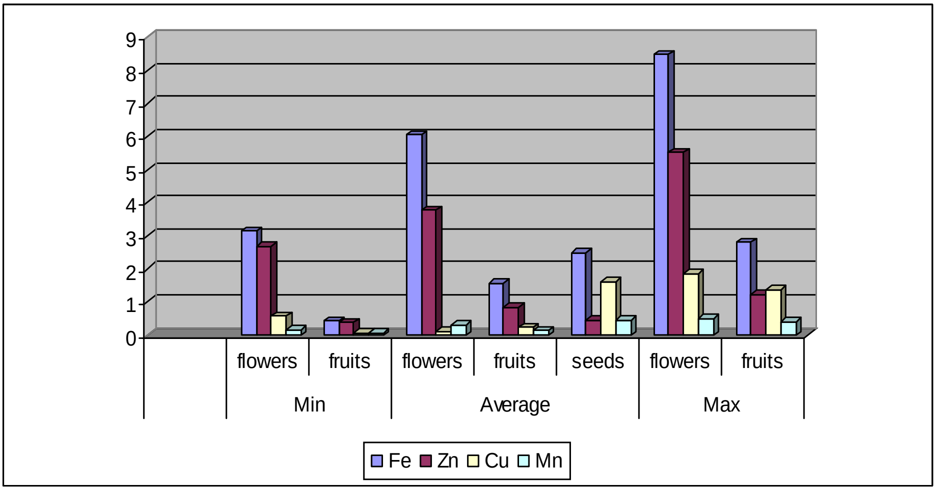

Figure 2. The content of microelements in the flowers and fruits of Chaenomeles, mg 100 g-.

Table 2. Content of essential elements in the flowers and fruits of *Chaenomeles*, mg 100 g- (on dry weight basis).

Breeding forms	Plant material	K	Ca	Mg	Fe	Zn	Cu	Mn	Σ*
XK-2-1	flowers	2433. 9	136. 1	393. 4	8. 48	2. 78	0. 57	0. 36	2975. 6
	fruits	1173. 6	179. 6	40. 8	0. 42	0. 72	0. 28	0. 09	1395. 5
P-8-3	flowers	2386. 1	186. 0	413. 4	7. 31	5. 51	1. 87	0. 49	3000. 7
	fruits	1450. 0	479. 1	63. 2	1. 61	1. 23	0. 37	0. 19	1995. 7
P-5-11	flowers	2279. 8	221. 0	334. 6	3. 14	3. 83	0. 92	0. 37	2843. 7
	fruits	1175. 7	344. 5	128. 4	2. 09	0. 87	0. 33	0. 25	1652. 1
P-5-9	flowers	2443. 4	113. 6	412. 9	3. 74	5. 26	0. 67	0. 32	2979. 9
	fruits	1205. 4	275. 3	163. 2	1. 18	0. 84	0. 37	0. 11	1646. 4
PX-4-4	flowers	2030. 9	155. 0	375. 5	3. 41	2. 69	0. 77	0. 15	2568. 4
	fruits	1601. 2	228. 9	72. 3	1. 45	0. 67	0. 07	0. 07	1904. 7
PX-5-15	flowers	1699. 8	139. 4	422. 3	7. 54	3. 11	0. 83	0. 26	2273. 2
	fruits	1432. 8	251. 3	108. 9	0. 98	0. 77	0. 11	0. 17	1795. 0
PX-3-10	flowers	1750. 0	226. 2	291. 1	8. 67	3. 14	0. 79	0. 17	2280. 1
	fruits	1915. 5	266. 1	116. 1	2. 1	0. 76	0. 28	0. 10	2300. 9
P-1-2-1	flowers	2421. 8	116. 8	371. 3	6. 15	3. 81	1. 71	0. 31	2915. 8
	fruits	1074. 4	292. 6	41. 1	1. 32	0. 81	0. 14	0. 09	1410. 5

*The total content of macro- and microelements.

Table 3. Contents of essential elements in jams, mg 100 g^{-}

Product	K	Ca	Mg	Fe	Zn	Cu	Mn
Apricot jam*	152	12	9	1	**	**	**
Apple jam*	129	14	7	13	**	**	**
Chaenomeles jam	2087. 2	39. 8	9. 7	0. 8	0. 08	0. 04	0. 02
The daily human need in mg ***	300 – 3000	800 – 1600	500 – 750	10–20	12–20	1, 0 – 2, 0	2, 0 – 5, 0

* –data on the requirements of SOSD.
** –data of SOSD are not provided.
*** – daily consumption rate depends on the age, sex, state of health and physical activity of the person (Scalny, 2003).

The total amount of essential elements in the fruit is 35% less than in the flowers. In addition, it decreases during the ripening, although for the separate elements it is not impossible to say definitely. The content of K, Ca and Zn is reduced, and the Fe and Cu is particularly increased (Dzhan *et al.*,2010a). The largest amount of Ca was detected in chaenomeles fruits among the studied plant parts. It reaches an average 289. 7 mg 100 g^{-}. By the amount of Ca and Fe chaenomeles fruits exceed the apples, pears, cherries, apricots, strawberries inseveral times, and can serve as a source of these elements (Komar-Tyomnaya *et al.*,2000, Iliashenko, 2012). It is thought thatthechaenomeles fruits are far superior to the apples on the content of K, Ca, Mg, and a less superior on the amount of Fe (Skalny, 2003).
The average total content of essential elements in the seeds decreases even more. It is 60% less than in flowers, and 39% less than in the fruit. However, seeds remain an important source of microelements. The highest amount of Mn (0. 46 mg 100 g^{-}) and Cu (1. 62 mg 100 g^{-}) has been found in seeds. They are approaching to the fruits on the Ca content and to the flowers on the content of Zn. As well as flowers, they are characterized by relatively high accumulation of Mg in contrast to the fruit.
The studied genotypes differ significantly in accumulation of essential elements. Such featureallows to conduct the breeding for these characteristics. Among the chaenomeles accessionsthe highest content of K in the flowers was observed in P-1-2-1, XK -2-1 and P-5-9, Ca – in the P-5-11 and PX-3-10, Mg – in the XK-2-1, Fe – in the XK-2-1 and PX-3-10, Zn – in the P-8-3 and P-5-9, Mn – in the P 8. 3, Cu – in the P-8-3 and P-1-2-1. According to the maximum content of these elements in the fruits the selection forms were distributed as follows: K – PX-3-10, Ca – P-8-3, Mg – P-5-9, Fe – PX-3-10, Zn – P-8-3, Cu – P-5-9, Mn – P-5-1. According to the studied complex components the P-8-3 is allocated. Its flowers are characterized by

the highest content of Ca, Zn, Mn, Cu and high – K, fruits are rich in K, Ca, Zn, Mn and Cu.

Considering the difference in the accumulation of micro- and macroelements in the flowers and fruits of some genotypes, we can assume the prospectivity of chaenomeles breeding on the maximum content of separate elements or complex elements.

In the jam from the chaenomeles fruit, high content of K (2087 mg 100 g^{-}, i. e. more than 2%) was revealed, which represents almost 7 maximum rate of daily human needs (Table 3). This is significantly higher than industrial products: 13. 7 times higher than in the apricot jam, and 16. 2 times higherthan in the apple jam. That is, 143. 7 g of jam from the chaenomeles fruit made in Nikita Botanical Gardens laboratory contains the maximum rate, and 14. 4 g – the minimum rate of daily human needs in this important element. Concerning the content of Ca, the chaenomeles jam had 3. 3 times higher calcium content than the industrial standard of apricot jam and 1. 4 times higher than apple jam. The amount of Mg in the chaenomeles jam is 1. 4 times higher than in apple jam and a little higher than in the jam from apricots. In regard of Fe, the chaenomeles jam is slightly inferior to industrial products. This element is contained 1. 2 times less than in the apricot jam and 1. 6 times less than in apple jam. Besides these elements, the chaenomeles jam contains microelements zinc, manganese, belonging to the essential group.

CONCLUSION

It was revealed that essential elements accumulated in the flowers and fruits in different quantities. The maximum amount of K, Fe, Zn, Mn and Cu is contained in the flowers. The largest amount of Ca was detected in chaenomeles fruits and Zn, Mn and Cu – in seeds. The studied genotypes differ significantly in accumulation of essential elements. According to the studied complex components, P-8-3 was allocated. Its flowers are characterized by the highest content of Ca, Zn, Mn, Cu and high content – of K; fruit are rich in K, Ca, Zn, Mn and Cu. In the jam from the chaenomeles fruit, high content of K was revealed, which represents almost 7 fold maximum rate of daily human needs. Thus, chaenomeles flowers, fruits and seeds are a valuable raw material, enriched with vital macro- and microelements.

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