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CONTENT OF VITAMIN C IN THE FRUITS OF JUJUBE (*ZIZIPHUS JUJUBA MILL.*) VARIETIES AND THEIR PROGENIES

SUMMARY

We have investigated the content of very important bioactive compound such as vitamin C in fruits of six varieties of Chinese jujube progenies: Zu tao czao, Da bai czao, Kitaiski 2A, Wild midleasian jujube type, Ja czao and Vahshski 45-2. It has been studied the inheritance of the vitamin C content in the fruits of 131 types in progenies, which were obtained from crossing of those six Chinese jujube varieties by open pollination, considering of the high jujube variety self-incompatibility. Studies were done on the plants that were 7-9 years old, or in full fertility.

Fruits from variety Da bai czao have the highest content of vitamin C (370.7 mg/100 g fruit). Compare with the other varieties, the fruit from variety Kitaiski 2A is characterized with the lowest content of vitamin C (185.2 mg/100 g fruit), and it's progeny, on the contrary, is characterized with the highest content of vitamin C in average (290.8 mg/100 g fruit), compare with the other investigated progenies. The largest number of the types in progeny with content of vitamin C higher than 300 mg/100 g fruit were characterized the varieties Zu tao czao and Da bai czao.

Keywords: Fruit, Chinese jujube, open pollination, type, variety, vitamin C

INTRODUCTION

The jujube fruits are rich with bioactive compounds which are very important for human health. The laboratory investigations show that the jujube fruits contain 20-28% total sugars, 0.3-2.5% total acids, 2.9% proteins, 500-600 mg of the vitamin C (in 100 g fruit pulp), vitamins from the B complex, and also they are rich source for minerals (Azam-Ali S. et al., 2006). According to literature data (Mratinic E., 2012) for other fruit kinds, the jujube fruits are in the very top by the content of vitamin C. The vitamin C is the most investigated and described between the vitamins, with a powerful influence on many biological processes. Such as strong antioxidant, vitamin C, participate in collagen and carnitine synthesis and in metabolism of the fatty acids. L-Ascorbic acid, the

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active biological form of vitamin C, is mostly presented in plants. The primates, including humans, cannot make vitamin C in their bodies and the primary source of the vitamin C are fruits, vegetables and fresh meat, among them the fruits are the richest sources for this vitamin (Hernández Y., et al, 2006). The ascorbic acid in jujube fruits is concentrated in the deep layers of the mesocarp, around the seed, and not below the peel, which is the case with other fruit kinds.

It is quite stable in jujube fruits during thermal processing of the fruits (the compotes and jams from jujube fruits contain usually 150-200 mg vitamin C) (Surhaev G., 2006). The vitamin C content in the jujube fruits decrease 8-10 times, 20 days after the harvest. It's enough to take only one fresh jujube fruit per day to reach the adult needs for the vitamin C and vitamin B complex as "recommended daily allowance (RDA)" by FAO (Azam-Ali et al, 2006). The highest content of the vitamin C is found in the time before fruits ripening (Markovski et al., 2009). This vitamin content rise from fruit's stone to peel and from fruit's remains of style to pedicel according to Bowe C. (Azam-Ali et al., 2006). The high content of vitamin C quantitatively inherited into some fruits as in fruits of the tomato varieties. Also, according to Stevens et al., (2007) the vitamin C content in tomato fruits is quantitatively inherited, that is shown with "quantitative trait locus (QTL) mapping" for ascorbic acid. Our investigations are focused on content of the vitamin C in jujube varieties and their progenies fruits, with aim to examine the inheritance of this characteristic. Using the results from the investigation, it is expecting to know which of the jujube varieties and types can be used as parents for obtaining the hybrids with higher content of the vitamin C in further breeding process (Yoo et al, 2012).

MATERIAL AND METHODS

The three year investigations in the selection orchards of Agricultural Institute in Skopje, Macedonia were performed with planting distance of 4 x 2 m, planted in 1997 with two years old seedlings of Chinese jujube varieties. During the investigations plants were 7-9 years old, apropos that were in the beginning of full fruitfulness (Markovski A. et al, 2015). The plants were grown without intervened pruning, left to develop naturally shaped crown, specific for each genotype. About 130 genotypes in the progenies which were obtained by open pollination between six Chinese jujube introduced varieties were examined. 35 seedlings of each variety-mother were planted in (with 38% surviving loses in total). As a control were used grafted trees of six varieties-mothers obtained with grafted technique whip grafting, in three repetitions, performed in 1998 (Markovski, A. Petkovski, D. 2012).

Determination of the content of vitamin C was performed by "volumetric method by titration with DCPIP" (dichlorophenol indophenol) (Papuc C. et al, 2001).

The examined characteristic was variational statistically analysed and tested by "Fisher LSD test" at two levels of probability (0.05 and 0.01).

The genetic parameters was estimated according to Wolie A. et al. (2013) biometrical methods and formulas to finding: Genotypic co-efficient of variation (GCV) = $(\sigma_g / \bar{x}) \times 100$, Phenotypic co-efficient of variation (PCV) = $(\sigma_p / \bar{x}) \times 100$, Heritability (H^2) = $(\sigma_g^2 / \sigma_p^2) \times 100$, and Genetic advance (GA) = $k H^2 \sigma_p$, where, σ_p = phenotypic standard deviation, σ_g = genotypic standard deviation, \bar{x} = grand mean for the characteristic, σ_g^2 = genotypic variance, σ_p^2 = phenotypic variance, and k = selection differential (at 5% selection intensity).

RESULTS AND DISCUSSION

The investigations show high content of vitamin C in the Chinese jujube varieties and progenies fruits. From the mother varieties with the highest content of the vitamin C in the fruits is characterized the variety Da bai czao (370.7 mg/100 g fruit), while with the lowest, almost double less content of vitamin C is characterized the variety Kitaiki 2A (185.2 mg/100 g fruit). It is found that the size of the varieties fruits has no influence on content of the vitamin C. For example, the variety Vahshski 45/2 which is characterized with large fruits and the variety Da bai czao with the smallest fruits from all investigated varieties have high content of the vitamin C in the fruits. The content of the vitamin C in fruits of the Chinese jujube is very high, even higher than any other species from *Ziziphus* genus such a ber-Indian jujube (*Ziziphus mauritiana* L). It's proposed for plant breeders to planning the interspecies breeding programs for obtaining the hybrids with maximum fruit size of the Indian jujube and content of vitamin C of the Chinese jujube (Azam-Ali S. et al., 2006).

The coefficient of variation of the vitamin C content in Chinese jujube types fruits from progenies of the Chinese jujube varieties ranges between 18-22% (Table 1).

A difference in the average content of the vitamin C among the types from the progenies is three times lesser (52.9 mg/100 g fruit) than the differences in the average content of the vitamin C among the mother varieties (185.5 mg/100 g fruit).

The significant statistical difference in the average fruit vitamin C content between the Chinese jujube varieties and types in the progenies is determined, with exception of the difference in the fruits vitamin C content between the varieties Zu tao czao and Da bai czao and their progenies. Very significant statistical difference in vitamin C content is determined between the some types in the progenies of the varieties Zu tao czao (7 types) and Kitaiki 2A (10 types) compared with their mother varieties. In the progenies of the other mother varieties the types with the highest vitamin C content in the fruits statistically significant does not differ from the mother varieties. The ascorbic acid content is depends from the period of fruit ripening, or late ripening Chinese jujube varieties have the highest content of vitamin C, while the content of catechin decreased up to 20 times below of the level at the beginning of the fruit ripening period. Between the content of this two compounds a high correlation coefficient is determined during the fruit ripening period (Thayer, J., 2012).

Table 1. Content of the vitamin C (mg/100 g fruit) in fruits of the jujube progenies.

	Zu-tao czao		Da bai czao		Ja czao		Wild midleas.		Vahshski 45/2		Kitaiski 2A	
	Type	mg/100 g	Type	mg/100 g	Type	mg/100 g	Type	mg/100 g	Type	mg/100 g	Type	mg/100 g
P	13/1	428.6	30/2	419.1	12/3	346.0	17/4	400.1	26/5	328.6	13/6	411.2
	25/1	385.2	15/2	360.8	19/3	315.2	16/4	374.9	15/5	321.0	33/6	388.7
	20/1	349.2	22/2	359.9	10/3	303.8	28/4	333.6	16/5	316.4	22/6	338.2
R	10/1	325.8	35/2	353.7	22/3	301.0	14/4	333.4	7/5	285.5	37/6	300.6
	17/1	324.7	13/2	338.7	14/3	283.6	31/4	307.7	27/5	279.1	40/6	285.5
	33/1	324.2	31/2	336.1	38/3	264.8	21/4	290.8	32/5	262.4	9/6	271.6
O	29/1	310.2	11/2	333.0	13/3	264.7	22/4	274.1	23/5	256.3	24/6	270.4
	8/1	291.1	7/2	325.0	24/3	257.8	35/4	267.1	35/5	251.7	14/6	255.4
	16/1	290.4	25/2	310.0	23/3	237.9	29/4	264.5	17/5	239.7	21/6	250.8
G	21/1	290.0	21/2	306.6	26/3	237.2	23/4	260.0	25/5	222.8	31/6	227.5
	34/1	289.6	23/2	299.4	15/3	236.2	26/4	258.0	38/5	212.5	23/6	198.7
	15/1	284.0	14/2	283.6	21/3	231.6	13/4	256.4	31/5	210.3		
G	22/1	281.8	37/2	278.6	33/3	213.1	24/4	227.4	18/5	203.0		
	27/1	272.4	32/2	269.6	32/3	212.6	34/4	220.2	33/5	196.7		
	11/1	272.1	33/2	268.5	16/3	210.9	25/4	204.4	6/5	189.7		
N	35/1	268.4	3/2	260.0	17/3	206.2	27/4	195.8	19/5	131.8		
	37/1	261.7	8/2	252.8	31/3	180.4	18/4	189.1	24/5	123.9		
	26/1	254.2	29/2	242.9	30/3	177.8	19/4	171.5				
I	28/1	250.1	26/2	240.4	25/3	175.2	32/4	163.0				
	32/1	236.6	36/2	238.0	20/3	174.6						
	18/1	231.7	28/2	234.8	37/3	168.9						
E	7/1	230.9	19/2	217.1	28/3	160.5						
	6/1	226.3	18/2	217.0								
	23/1	224.7	17/2	211.7								
S			9/2	177.1								
			6/2	173.8								
CV %		18		22		22		18		22		22
Lsd _{0.05}		55.7		100.9		59.2		72.2		50.1		38.7
Lsd _{0.01}		74.1		134.2		78.7		96.0		66.7		51.5

The Kitaiski 2A progeny is characterized with the highest content of the vitamin C among the progenies (290.8 mg/100 g fruit), while the Ja czao progeny has the lowest content of the vitamin C (235.4 mg/100 g fruit). The types from the Kitaiski 2A progeny are clearly separated from types from others progenies, especially above the range of 260 mg vitamin C/100 g fruit. Otherwise, below that range (260 mg/100 g fruit) are stand out the most of the types from the Vahshski 45/2 and Ja czao progenies. The mother varieties which have in average

the lowest content of vitamin C (Kitaiski 2A and Zu tao czao) gives progeny with the highest content of vitamin C in average (Table 1).

The type 13/1 from the progeny of the mother variety Zu tao czao is characterized with the highest content of vitamin C (428.6 mg/100 g fruit).

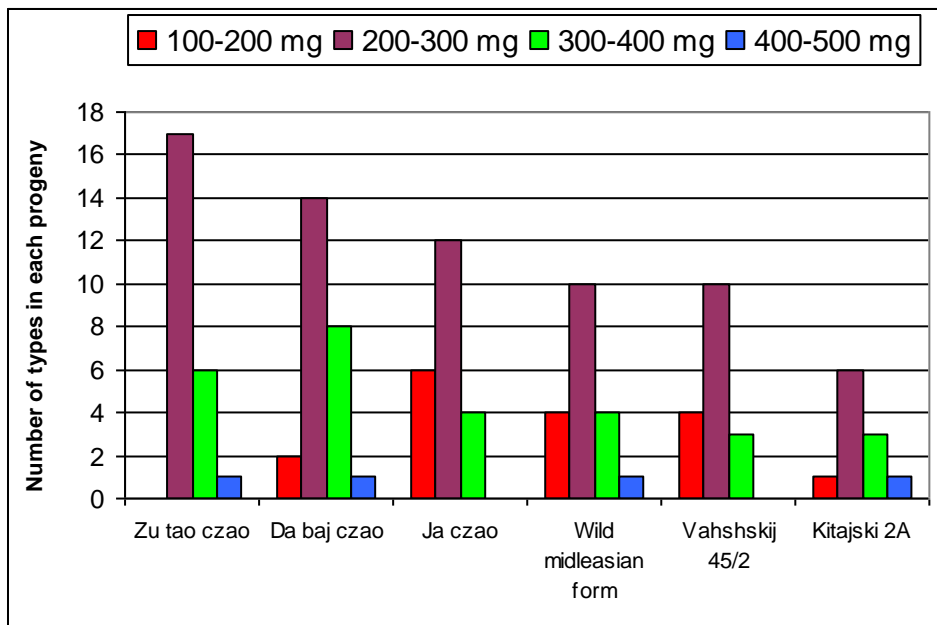


Figure 1. Four group of distribution of the types in progenies by content of the vitamin C (mg/100 g fruit).

Actually, only four types (13/1, 30/2, 13/6 and 17/4) are characterized with higher content of vitamin c over 400 mg/100 g fruit, also only few types (13/1, 30/2, 13/6, 17/4, 25/1, 16/4 AND 33/6) from the progenies have higher content of vitamin c than the mother variety with the highest content of vitamin c, da bai czao (370.7 mg/100 g fruit).

The presence of vitamin c in the types from the progenies is the best expressed in the figure 1. Especially is important the types number in the progenies which belong to the second (200-300 mg/100 g fruit) and third group (300-400 mg/100 g fruit), by the content of vitamin c.

These two groups are presented mostly in the progenies of the varieties zu tao czao and da bai czao, or 17 types in the second and 6 types in the third group from progeny of the zu tao czao and respectively 14 types in the second and 8 types in the third group in the progeny of da bai czao.

Can be noted that the variety kitaiski 2a despite that has in average the highest content of vitamin c in the progeny, also has considerably the lower number of types with high content of the vitamin c in total, than the varieties zu tao czao and da bai czao. Ascorbic acid content in varieties da bai czao and nikitskii 17 researching in yalta, crimea (russia) shown differ results than ours, or

almost double content of the vitamin c (774 mg/100 g fruit) and also high pectin content in some chinese jujube varieties (up to 1%). It indicates that in the northern countries fruits of the same chinese jujube varieties have greater content of vitamin c. Among 25 chinese jujube varieties are made the different lists of the best varieties depending of the used postharvest fresh handling and processing technologies, according to sinko l.t., (Surhaev g., 2006).

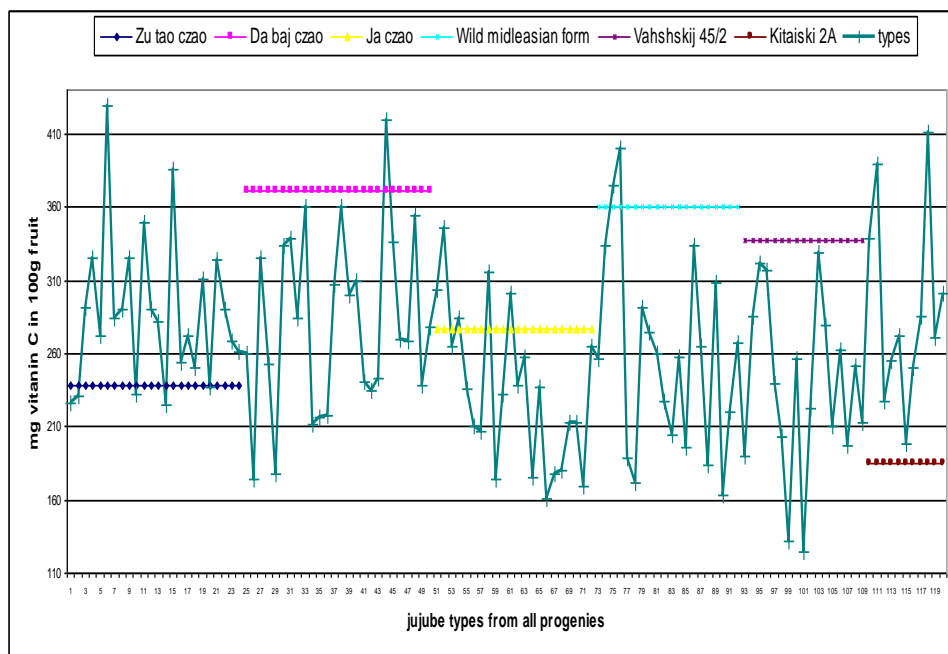


Figure 2. Comparison of average content of the vitamin C, between mother (varieties horizontal lines) with types in progeny (zig-zag lines).

The variety da bai czao produce the progeny with the greatest number of types (8) which belong to second group (300-400 mg/100 g fruit) by content of vitamin c. The progeny of the variety ja czao has the greatest number of the types with low content of vitamin c in the fruits (100-200 mg/100 g fruit). The evaluation of many chinese jujube varieties in south-west turkmenistan, shown that with the best bioactive compounds content is characterized the variety ja czao according to lomakina m.i., (azam-ali s et al., 2006).

Among the varieties da bai czao, ja czao, wild midleasian and vahshski 45/2 is recorded weak influence of variety to content of vitamin c in fruits of the types from their progenies, where the mothers have the higher content of vitamin c than the most of the types in their progenies. The exceptions are the varieties zu tao czao and kitaiski 2a where the most of the types have higher content of vitamin c in the fruits than their mothers (Figure 2.).

The determination of the genetic parameters clarify the investigated characteristic variation in progenies (Table 2).

Table 2. Genetic parameters for vitamin C content of the jujube genotype fruits

Variety progenies	Range			Genetic parameters			
	Min. mg /100g	Max. mg /100g	Mean mg /100g	GCV (%)	PCV (%)	Heritability (%)	GA (%)
Zu tao czao	224.7	428.6	287.7	9.7	18.2	49.8	8.8
Da bai czao	173.8	419.1	281.1	22.7	33.4	21.6	7.1
Ja czao	160.5	346.0	234.5	13.6	25.5	47.6	11.8
Wild	163.0	400.1	258.8	13.6	27.0	50.4	13.2
Vahshski 45/2	123.9	328.6	237.2	8.6	20.9	57.6	11.7
Kitaiski 2A	198.7	411.2	290.8	4.3	15.0	62.9	9.2
All progenies	160.5	428.6	287.6	34.3	46.2	45.1	19.7

The genotypic coefficient of variation (gcv) indicate for much higher variability of all genotypes in progenies than in the frame of the separate single mother-variety progeny. Considering that, the bigger are the values of gcv, heritability and genetic advance (ga) for some characteristic, same characteristic can be more improved through the selection process (islam m.n. et al., 2010), therefore at chinese jujube for the same purpose is recommended using of a larger number of parents in the hybridizations. The difference between gcv and phenotypic coefficient of variation (pcv) suggested for some environment influence which is not too much expressed. Heritability is an important genetic parameter that measures the relative degree to which a character is transmitted from parent to progeny (fotrić akšić m, et al, 2011). The percent of heritability is higher in the progeny of the mother variety kitaiski 2a (62.9%), which is mean that in this variety is much easier the obtaining of inheritance with high content of the vitamin c in fruits, through individual selection. However, moderate to low heritability and genetic advance suggested for polygenic influence and quite weak additional gene effect (kitaiski 2a) in creation of the characteristic for content of vitamin c in the chinese jujube fruits.

On basis of the obtained results, with aim to perform individual selection of types by production of vitamin c, are investigated the dependents on it with total yield of fruits, the size of the fruits, and also the volume of the tree crown of the types (markovski, petkovski, 2012) (table 3). By the evaluation of the yield (kg per tree) it is found that the type 17/4 is characterized with the highest production of vitamin c in fruit (44 g vitamin c per tree). If we considered the vigour of the type or yield kg/m³, then with the highest production is characterized the type 15/2 (12.3 g vitamin c per m³ volume of the crown). The variety zu tao czao participate with the greatest number of types among the first four with the highest production of vitamin c per tree and also per volume of the crown (Table 3).

Table 3. Top ten types with the highest production of vitamin C in the fruit, from all obtained jujube progenies.

Type	Vitamin C mg/100 g fruit	Mass of fruits g	Yield kg/tree	Yield per crown kg/m ³	Vitamin C production	
					g/m ³ crown	g/tree
17/4	400.1	9.4	11.0	0.1	0.5	44.0
20/1	349.2	12.3	11.4	1.2	4.1	39.8
25/1	385.2	9.0	5.6	0.2	0.8	21.6
37/6	411.2	3.9	5.2	0.9	3.7	21.4
15/2	360.8	3.1	4.1	3.4	12.3	14.8
16/4	374.9	1.8	3.9	0.3	1.3	14.6
22/2	359.9	4.7	3.9	0.7	2.3	14.0
12/3	346.0	7.9	3.3	0.1	0.4	11.4
13/6	388.7	3.4	1.0	1.4	5.6	3.9
13/1	428.6	4.1	0.8	1.3	5.7	3.4

CONCLUSIONS

The investigation in general shown that the content of the vitamin C in Chinese jujube varieties progenies inherited intermediate, but in some progenies such as the progeny of Kitaiski 2A and Zu tao czao the inheritance is partial dominantly, compared with the mother variety. The varieties Zu tao czao and Da bai czao produced the largest number of types with high content of the vitamin C, and is recommended using of these two varieties in further breeding programs.

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