Harvest-Dependent Chemical Components in *Cucumis sativus L.* Fruits: I. Salad Cucumbers

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Introduction: Chemical composition is important to fruit quality in fresh market or salad cucumbers. Indirect information regarding the organoleptic and nutritive properties of fruits of different cultivars can be obtained by an analysis of dry matter, monosaccharides, and titratable organic acids. Monosaccharides improve the taste density of fruit, while their refreshing properties are mainly due to free organic acids. Ascorbic acid is a substance having antioxidant effect, and it is a significant component of a fruit's biological value (3, 4, 6). The abundance of these substances in the salad cucumbers intended for fresh consumption is of great importance.

The concentration of these basic substances in cucumber fruits, however, is comparatively low and varies among varieties (7). In order to form appropriate conclusions from chemical analyses, it is very important to clarify the effects of sampling time prior to analysis.

Cucumber possesses an extended, continuous fruiting habit. The picking of fruit is carried out on fruits taken from multiple harvests. At each harvest plants are in different stages of maturity, fruits are located at different distances from the root system, and are matured under different light, temperature, humidity, and soil nutrient supply. The purpose of the present study is to estimate the effects that the microclimate at different harvests has on the monosaccharides, titratable organic acid, and ascorbic acid accumulation in the fruit of salad cucumbers. This was investigated using a diverse array of breeding lines.

Materials and Methods: The experiment was performed during 2001 to 2002 in a polyethylene greenhouse. Six salad cultivars possessing different morphological characteristics were studied: *Bistrenski* – monoecious, fruit length 20 –24 cm; *Midori* F_1 – gynoecious, 15 –18 cm fruit length; *Desislava* F_1 – gynoecious, 22 – 25 cm fruit length; *Gergana* – monoecious, 28 – 30 cm fruit length; *Linia* 61 – monoecious, length of the fruit 28 – 30 cm; and *Lora* F_1 – parthenocarpic, gynoecious, length of the fruit 33 – 35 cm.

Entries were arranged in a randomized complete block design with four replications at 100 and 50 x 45 cm planting scheme where the area of an experimental plot was 3.4 m^2 each containing 10 plants. The seeds were sown on 23 March, and the plants were maintained until 30 July.

Fruits from each of three harvests were analyzed where the harvest interval was every 15 days. The first harvest was carried out 66 – 73 days from the date of plant germination, the second one– 90 – 98 days, and the third – 110 – 117 days. The content of dry matter, monosaccharides and ascorbic acid was determined according to the method of Shoorl-Regenbogen (2) using the reaction of Tilmans. Titratable organic acid concentration was obtained by direct titration of juice with 0.1 n NaOH taking the average of 10 plants in each replication.

Results were analyzed by two-way analysis of variance (3), means were separated using Duncan's multiple range test (1), and correlations were made between varieties for each of the three substances (3).

Results and Discussion: The concentration of the substances studied varied depending on harvest date (Table 1). A systematic increase or decrease in their amounts was not observed. Significant correlation coefficients for the dry matter content between II-nd and III-rd harvesting during the first experimental year and between 1st and 2nd harvesting during the second experimental year were greater than 0.5 (Table 2a). In the other treatments, correlation coefficient values were low. The relationship between the dry matter content in fruits taken over the three harvests was not unidirectional. General trends regarding the correlation coefficients of ascorbic acid, titratable organic acids and monosaccharides content were similar (Tables 2b, c, d). Thus, based these results it appears possible to predict the concentration of these

Table 1. Chemical components in salad cucumber fruits.

Cultivars	Time of harvesting	Dry matter (%)		Ascorbic acid (mg %)		Titratable organic acids (%)		Monosaccharides (%)	
		2001	2002	2001	2002	2001	2002	2001	2002
Midori	I	3.90 b	4.50 n.s.	13.14 n.s.	9.21 c	0.08 n.s.	0.14 a	1.79 b	1.90 n.s.
	II	4.64 a	4.78 n.s.	9.14 n.s.	11.52 b	0.08 n.s.	0.11 b	1.94 ab	2.04 n.s.
	III	4.62 a	4.75 n.s.	11.13 n.s.	13.48 a	0.09 n.s.	0.08 c	2.30 a	2.07 n.s.
Bistrenski	I	4.22 n.s.	4.57 ab	14.59 a	11.03 n.s.	0.14 a	0.09 n.s.	1.83 n.s.	1.92 n.s.
	II	4.20 n.s.	4.80 a	9.70 b	11.86 n.s.	0.07 b	0.10 n.s.	1.68 n.s.	2.01 n.s.
	III	4.30 n.s.	4.26 b	13.98 a	11.14 n.s.	0.10 b	0.08 n.s.	2.14 n.s.	1.76 n.s.
Gergana	I	4.04 b	4.46 n.s.	12.61 n.s.	8.58 b	0.10 n.s.	0.11 n.s.	1.74 b	2.22 n.s.
	II	4.74 a	4.56 n.s.	13.17 n.s.	11.30 a	0.10 n.s.	0.10 n.s.	2.09 a	2.24 n.s.
	III	4.70 a	4.90 n.s.	13.78 n.s.	11.20 a	0.10 n.s.	0.09 n.s.	2.14 a	2.02 n.s.
Desislava	I	4.54 n.s.	4.33 b	14.80 n.s.	9.56 b	0.08 n.s.	0.12 n.s.	2.02 n.s.	1.78 b
	II	4.84 n.s.	5.20 a	14.31 n.s.	12.64 b	0.09 n.s.	0.10 n.s.	2.09 n.s.	2.37a
	III	4.89 n.s.	4.52 b	12.34 n.s.	18.34 b	0.10 n.s.	0.10 n.s.	2.12 n.s.	1.94 b
Lora	I	4.34 n.s.	3.93 n.s.	12.15 n.s.	8.65 b	0.08 b	0.11 b	2.01 n.s.	1.62 c
	II	4.42 n.s.	4.46 n.s.	15.01 n.s.	12.14 ab	0.09 ab	0.10 c	1.98 n.s.	1.98 a
	III	4.54 n.s.	4.32 n.s.	14.43 n.s.	14.06 a	0.10 a	0.14 a	2.20 n.s.	1.84 b
Linia 61	I	3.89 b	4.30 n.s.	13.74 a	8.38 b	0.12 a	0.13 a	1.58 b	1.86 n.s.
	II	4.48 ab	4.90 n.s.	9.63 b	11.93 ab	0.08 b	0.10 c	1.92 ab	2.29 n.s.
	III	4.81 a	5.17 n.s.	11.42 b	17.26 a	0.10 ab	0.11 b	2.25 a	2.26 n.s.

a, b, c… - Duncan's multiple range test ($p<0.05$), n.s. – not significant

Table 2. Coefficients of correlations between studied chemical components

← 2002

	I	II	III
I	♦	0.515	-0.060
II	-0.046	♦	0.025
III	0.115	0.599**	♦

2001 →

a) dry matter

← 2002

	I	II	III
I	♦	-0.029	-0.352
II	-0.152	♦	0.351
III	-0.010	0.485	♦

2001 →

b) ascorbic acid

← 2002

	I	II	III
I	♦	0.534	0.108
II	-0.446	♦	-0.466
III	0.131	-0.070	♦

2001 →

c) titratable organic acids

← 2002

	I	II	III
I	♦	0.157	0.202
II	0.044	♦	0.429
III	0.176	-0.140	♦

2001 →

d) monosaccharides

Table 3. Two-way analysis of variance for studied chemical components in salad cucumber fruits depending on cultivar (factor A) and time of harvesting (factor B)

Experimental year	Chemical components	Factors influence (ŋ%)			
		Cultivar (A)	Time of harvesting (B)	A x B	Error
2001	Dry matter	21.34*	39.26***	18.51	20.89
	Ascorbic acid	25.70*	11.34*	40.53*	22.43
	Titratable org. acids	16.78*	13.35**	55.14***	14.63
	Monosaccharides	10.18	46.70***	21.22	21.90
2002	Dry matter	25.56**	33.82***	25.19*	15.43
	Ascorbic acid	12.74**	54.22***	24.13**	8.91
	Titratable org. acids	26.99***	16.31***	50.00***	6.70
	Monosaccharides	33.25***	27.25***	26.50**	13.01

substances based on information from a single harvest.

With rare exceptions, differences in the substances studied were recorded during the three harvests (Table 1). Given the significant mean treatment differences, it is possible to divide data for dry matter content and monosaccharide content into two groups. For some cultivars, three groupings for the ascorbic acid and titratable organic acids was possible for each of the harvests. Therefore, harvesting date is influential affecting the concentration of the chemical substances studied.

This hypothesis was confirmed by two-way analysis of variance of concentration differences (Table 3). The influence of factor B (time of harvesting) on the content of dry matter and titratable organic acids exceeds those of the factor A (cultivar). The results of ascorbic acid and monosaccharide concentration are variable. In fact, the effect of factor B for the whole experimental period is statistically significant, and is over 11 per cent. The influence of both factors was best expressed in the concentration of titratable organic acid.

The results indicate that the time of harvesting is an important factor in the accumulation of the substances studied and must be considered during data interpretation. It is impossible to make reliable conclusions from information obtained from one harvest. Likewise, it is impossible to predict a single optimal moment for carrying out chemical analyses of cucumber fruit. It is more correct to consider the designation of an optimal period of fruiting for the accurate determination of dry matter, ascorbic acid, titratable acids and monosaccharides. In the evaluation of salad cucumber breeding material it is very important to carry out obligatory chemical analyses several times over several harvests to increase the reliability of the results.

Literature Cited

1. Duncan, D. 1955. Multiple range and multiple F-test. Biometrics 11: 1-42.
2. Genadiev, A., Kalchev, D., Tevekeliev, N., Chavdarov, N. 1969. Analysis of food products. Tehnika, Sofia, p.695.
3. Lidanski, T. 1988. Statistical methods in biology and agriculture. Zemizdat, Sofia, 375 p.
4. Saimbhi, M. 1992. Nutritional composition of various vegetable crops – a review. Agricultural Reviews (Karnal) 13 (4): 209-218.
5. Soldatini, G. 2000. Phytochemical biodiversity and the health-related properties of foods. Georgofili 47: 11-53.
6. Valero, M., Fletcher, A., Stavola, B., Vioque, J., Alepuz, V. 2002. Vitamin C is associated with reduced risk of cataract in a Mediterranean population. Journal of Nutrition 132 (6): 1299-1306.
7. Velkov, N. 2003. Sources of resistance to causal agents of powdery mildew (*Sphaerotheca fuliginea (schlecht.:Fr) Poll* and *Erysiphe cichoracearum DC*) on cucumbers. PhD Thesis, Plovdiv, Bulgaria.