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Nutritive value of tomatillo fruit (*Physalis ixocarpa* Brot.)

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Abstract

Tomatillo is widely cultivated in Mexico but is little known in other countries. The chemical composition of fruit from field grown plants was investigated during several vegetative seasons. Tomatillo contained a relatively high percentage of dry matter (7-10%) and extract (6.6-7.4%). Its potassium content was lower than that of tomato growing in the same conditions. The content of iron was higher, and that of other elements was comparable, depending on the conditions during the given year. The total sugar content amounted to 2.8-5.7%, depending on the selected population. The percentage of glucose and fructose decreased during ripening and that of saccharose increased. The content of pectic substances was similar as in tomato but the proportions of particular fractions was different. Tomatillo contained more acids than tomato, and showed an especially high citric and malic acid content. The latter decreased drastically during ripening. The content of oxalic acid was 11-18 mg 100 g^{-1} in ripe fruit and up to 54 mg in unripe. The vitamin C content depended on the selected population and amounted to 8-21 mg 100 g^{-1}, dehydroascorbic acid prevailing. The content of vitamin PP was 0.8-1.3 mg 100 g^{-1}.

Key words: mineral salts, sugars, acids, pectic substances, vitamin C, vitamin PP, ripening, chemical composition

INTRODUCTION

Tomatillo, or husk tomato (*Physalis ixocarpa* Brot.), is a vegetable widely cultivated in Mexico for its fruit (Saray-Meza et al. 1978, Cartujano-Escobar et al. 1985. Mulato-Brito et al. 1985). It was also introduced to the USSR by the Vavilov expeditions (Medvedev 1958). Trials of its cultivation were also made in Spain (Cuartero et al. 1983). In Poland, it was introduced in 1983 by one of the authors (L.S.J.) and was found to grow satisfactorily in home gardens in the climate of Central Poland (Borkowski 1984, Jankiewicz et al. 1987). In the USA, tomatillo is cultivated, as far as we know, mainly in the regions where larger groups of people of Mexican origin live. Some companies sell its seeds in the USA (American Vegetable Grower 1986 Nr 12 p. 31).

The tomatillo plant grows similarly to the open ground tomato in Poland. It is sown in early April in a greenhouse and is usually transplanted to a field May 15-20th. The plant forms four apparent main axes which are usually tied to the strings extended between the sticks. It forms singular flower buds at each node. The fruit is similar to tomato but is green, yellow-green or violet. It is covered partly or entirely by an envelope formed from a very large calice. The main fruiting occurs in August and September and the yield reaches 15-40 t ha^{-1} (Vekhov et al. 1978, Garzon-Tiznado and Garay-Alvarez 1986, Jankiewicz and Borkowski in press).

In Mexico, tomatillo is consumed mostly in the form of sauces with hot pepper, which have Pre-Columbian origin. In Poland it has been introduced in the form of a jam, relish, with zucchini and hot pepper or in other processed forms. It is not very tasty in fresh form. It seemed interesting, therefore, to look at the nutritive value of this vegetable. There are very few data on this topic. Souza-Novelo (1950) gives the following data on the chemical composition of tomatillo (averages of 3 separate analyses):

Dry matter	7.8%	Vitamins (mg 100 g^{-1}):	
Proteins	0.57%	carotens	0.03
Fats	0.68%	thiamine	0.08
Cellulose	1.33%	riboflavin	0.04
"Total assimilable carbohydrates"	4.05%	niacin	2.05
		ascorbic acid	13.6-46

Calcium 20.3 mg 100 g^{-1} (= 258 mg 100 g^{-1} dry matter)
Phosphorus 236.6 mg 100 g^{-1} (= 3025 mg 100 g^{-1} dry matter)
Iron 28.2 mg 100 g^{-1} (= 297.4 mg 100 g^{-1} dry matter)

The investigations of this author concern the plants grown in a worm climate of the Yucatan.

The purpose of the present paper is to provide data on the main chemical constituents and vitamis in the fruit of several populations of tomatillo grown in experiments in central Poland.

MATERIALS AND METHODS

The plants were grown in the experimental garden of the Research Institute of Vegetable Crops in Skierniewice during 1984-1987. The soil contained a high percentage of organic matter and the plants were irrigated. In addition, some were grown in the non-irrigated field of our Institute during 1986-1987.

The soil there was of a sandy loam podsolic type, with about 1-1.2% organic matter and a pH of about 6.

The cv. Rendidora B1 was selected from the plants of a Mexican cv. Rendidora. The cvs. Antocyjanowa and Bujna originated from the fruit bought in the market in Mazatlan Sin. and Texcoco Méx., Mexico, respectively. The forms Bujna 1 to Bujna 5 were selected from the cv. Bujna. All these cultivars and forms show marked variability.

The plants were sown in a heated greenhouse about April 1-7. When they had well-formed cotyledons, they were transferred to an unheated plastic tunnel or to a hotbed, and about May 9-20th (depending on the weather) were planted in the garden or in the field. The plants started to fruit in mid-July; however, the main crop was in late August and early September. The cv. Rendidora B1 was the earliest; 'Bujna' and 'Antocyjanowa' were medium-late. It is important to remember that tomatillo plants flower up to late autumn, so that flower buds, flowers, fruitlets and ripened fruits are usually found on a plant at the same time. Tomatillo fruit may be eaten or processed when unripe or ripe. It is consumed almost exclusively after being processed.

CHEMICAL ANALYSES

The content of a given substance or element was always determined two or there times in a sample. Dry matter was determined after drying at 60°C.

The ash content was determined after drying, grinding and incinerating the fruit tissue at a temperature of 550-600°C.

Analysis of elements (K, Ca, Mg, Cu, Fe, Zn) was performed with an AAS-1-N absorption spectrophometer (East German production), according to Printa (1977).

Acidity was measured by the titration method (Iwińska et al. 1959). It was expressed as citric acid. Total sugars and monosaccharides were determined using the Luff-Schoorl method (Krauze et al. 1966). Oligosaccharides were calculated as the difference between total sugars (after inversion) and monosaccharides. The pectic substances were determined with carbazol (Rouse and Atkins 1955) Crude fats were determined by applying the extraction with ethyl ether method (see Brzeski and Kaniuga 1957).

Vitamin C was calculated as a sum of ascorbic and dehydroascorbic acids, using Tillmans' method modified by Pijanowski (Krauze et al. 1966). Vitamin PP was determined colorimetrically with sulfanilic acid (Williams 1984), and provitamin A (β-caroten) was determined by column chromatography (Saniewski and Czapski 1983). Nitrogen and proteins were determined using the Kjeldahl method (see Krauze et al. 1966). Total carotenoids were determined after hydrolysing the ether extract and extracting it afterwards several times with petrol ether (Sykut 1967).

Determination of sugars and non-volatile organic acids by gas chromatography. Previous authors (see Ford 1979) have shown that it is possible to determine mono-and oligosaccharides by gas chromatography using trimethylsilylation. We followed this idea.

The first part of the procedure was common for sugars and for non-volatile organic acids.

A half-kilogram of fruit was homogenized in a Waring Blender. Twenty-five grams of homogenate were mixed with 60 cm³ of 70% ethanol, and refluxed in a boiling water bath for 1 hour. The mixture was allowed to stand at room temperature until the next day. After adding about 2 grams of Cellite, it was filtered under vacuum, 70% ethanol was added to the filtrate to a volume of 100 cm³ (solution A).

Determination of particular sugars. Ten cm³ of "solution A" were diluted with 80% ethanol to 50 cm³. Afterwards, 100 mm³ of this solution were transferred to 2 cm³ screw cap vials containing 25 mm³ arabitol as an internal standard. The solution was dried in a stream of air. During evaporation the vials were heated to 60°C. They were then stored in a vacuum desiccator over phosphorous pentoxide. The dehydrated residue was silylated with 200 mm³ of silylation reagent, prepared by mixing TMS-imidazole with silylation grade pyridine (1:1, v/v). After stoppering, the vials were shaken and allowed to stand for 30 min. Then the samples were injected into a Pye Unicam 204 gas chromatograph, fitted with a hydrogen flame ionization detector. TMS-carbohydrates were separated in glass columns (1.5 m × 4 mm ID) packed with 3% OV-1 on GasChrom Q, 80-100 mesh. The temperature of the injector and detector ports was 250°C and 300°C, respectively. The column oven temperature was initially 149°C for 2 min., then raised 8°C per min to 285°C. Argon was the carrier gas at a flow rate of 25 cm³ per min. Hydrogen and air flows were 25 and 300 cm³ per min, respectively. Standards, fructose, glucose and sucrose, were dried over phosphorous pentoxide under vacuum and stored desiccated. Standards were derivatized as described above to calculate the ratio of peak height of the appropriate carbohydrate to peak height of internal standard. Response factors were linear over the ranges evaluated. Glucose was calculated as the sum of the α and β anomers.

In the determination of non-volatile organic acids, we followed the Sasson et al. (1976) method, with many modifications.

One cm³ of "solution A" (see above) was transferred to 2 cm³ vessels, containing 0.25 mg of internal standard (adipic acid), then the mixture was evaporated to dryness in a stream of dry air. During evaporation, the vessels were heated to 60°C. One cm³ of 14% BF_3-methanol complex was added to the dry residue, and allowed to stand overnight at room temperature. After adding to the reaction mixture 2 cm³ of 30% ammonium sulphate in a small separatory funnel, methyl esters of non-volatile acids were extracted twice by using 1 cm³ chloroform portions. The choroform extract was dried with anhydrous sodium sulphate. Four mm^3 of this solution were injected into a Pye Unicam 204 gas chromatograph equipped with a flame ionization detector and temperature programmer. A glass column, measuring 1.5 m × 2.0 mm (i.d.), filled with 10% Silar 10 C on Chromosorb W, 80/100 mesh, was used. It was maintained at 121°C for 1 minute, and then programmed at 6°C min^{-1} to 215°C. The detector was maintained at 250°C, the injector at 220°C. Carrier gas flow (Ar) was 25 cm^3 min^{-1}; hydrogen flow, 25 cm^3 min^{-1}; and air flow, 300 cm^3 min^{-1}.

The results of the determinations were calculated based on calibration curves for each analyzed acid. The curves were prepared by plotting various quantities of each organic acid vs. the corresponding R value, which was calculated as a ratio of the peak height of the appropriate acid to the peak height of the internal standard (adipic acid).

A statistical assessment of the results was done for the individual sugars and non-volatile acids with variance analysis method, using the "t" test for significance, at $P = 0.05$ or 0.01.

RESULTS

The dry matter content was rather high in tomatillo, from 7 to 10.0% in different populations and in different years (Tables 1 and 2). It was higher than in tomato cvs. New Yorker and Ostrawski Wczesny grown in comparable conditions. Ripe (yellow-green) and unripe (totally green) fruit of tomatillo collected from the same plants on the same date did not differ in dry matter content (Table 2). Fruit collected at different dates, but showing a similar degree of ripeness, showed a tendency to contain less dry matter at the later date (Table 1).

The content of the extract was higher in tomatillo than in tomato cv. Salto cultivated side by side (Table 3). The ash content in tomatillo amounted to 7.3-8.2% dry matter (Tables 1 and 4), and was less than in tomato cv. Salto (9.3%). The particular tomatillo cultivars did not differ markedly between each other in this respect (Table 4).

The content of minerals in tomatillo was somewhat different from that of tomato (Table 5). Tomatillo fruit contained less potassium and calcium and more sodium and iron. The fruit of these two species contained similar levels of zinc, and the differences in magnesium content were unstable. A comparison of three cultivars of tomatillo (Table 4) showed insignificant differences in mineral constituents. Nevertheless, the fruit of the plants cultivated in 1987 contained more potassium and zinc and less sodium and calcium (Table 4) than in 1984 and 1985 (Table 5) which may be ascribed to the somewhat different edaphic conditions in these years.

The pH of tomatillo cv. Rendidora B1 was a little lower than that of

Table 1

Comparison of chemical composition of tomatillo and tomato fruit

Constituents		Tomatillo cv. Rendidora B1				Tomato	
						cv. New Yorker	cv. Salto
	year	1984		1985		1984	1985
	date	08.13	09.04	08.05	09.02	08.13	08.05
pH		3.90	3.90	4.00	4.01	4.32	4.18
Acids (%)		0.72	0.72	0.52	0.47	0.35	0.46
Simple sugars (%)		1.58	1.62	1.72	1.47	2.89	3.63
Oligosaccharides (%)		3.11	3.17	4.02	2.18	0.04	0.00
Total sugars (%)		4.69	4.79	5.74	3.65	2.94	3.60
Ratio: sugars/acids		6.25	6.39	11.00	7.76	8.40	8.04
Dry matter (%)		8.05	7.80	10.0	7.0	5.75	6.4
Total carotens (mg 100 g^{-1})		0.14	–	–	–	8.6	–
Proteins (% dry matter)		12.25	14.00	14.9	14.0	14.0	11.4
Ash (% dry matter)		–	–	7.6	8.2	–	9.3

Table 2

Chemical composition of tomatillo cv. Rendidora B1 fruit depending on its stage of ripening. Fruit collected on September 2

Constituents	Phases of ripening		
	green	pale green	yellow or yellow-green
pH (units)	3.87	4.01	4.30
Acids (%)	0.59	0.42	0.40
Simple sugars (%)	1.95	1.47	1.45
Oligosaccharides (%)	0.94	2.18	2.82
Total sugars (%)	2.89	3.65	4.27
The ratio: total sugars/acids	4.89	7.76	10.67
Dry matter (%)	7.0	7.0	7.8
Ash (% dry matter)	7.68	8.19	7.80
Proteins (% dry matter)	14.0	14.0	15.7
Crude fats (% dry matter)	–	8.7	–

Table 3

Extract content (%) in tomatillo and tomato fruit

Species and cultivar	Date of collection in 1985				Average
	08.13	08.22	08.28	09.18	
Tomatillo cv. Rendidora B1	7.4	7.2	6.3	6.6	6.9
Tomato cv. Salto	5.6	5.5	5.4	4.8	5.3

Table 4

Mineral constituents (μg g^{-1} dry matter) in the fruit of several cultivars of tomatillo in 1987

Constituent	'Rendidora B1'	'Antocyjanowa'	'Bujna'
Na	285	243.8	230
K	32500	34250	36250
Ca	307	218	281
Mg	1125	1300	1200
Cu	15.0	15.5	13.7
Fe	61.3	66.8	63.1
Zn	166.3	168.8	150.6
Ash (%)	7.3	7.8	7.8

Table 5

Comparison of the mineral composition of tomatillo and tomato (μg g^{-1} dry matter)

Elements	Tomatillo cv. Rendidora			Tomato	
	1984.08.13	1984.09.04	1985.08.05	cv. New Yorker 1984.08.13	cv. Salto 1985.08.05
Na	317.5	307.0	453.5	287.5	223.5
K	24500	26500	27937	33400	33562
Ca	530	555	837	1590	1850
Mg	925	1287	2150	887	2600
Cu	6.5	7.8	15.8	9.7	12.3
Fe	–	–	130.0	–	81.8
Zn	35.2	46.6	71.2	33.7	69.3

tomato (Table 1). Concomitantly, the content of acids was higher. The acidity of unripen fruit was higher (Table 2). Among the three cultivars investigated, 'Antocyjanowa' showed the lowest pH and the highest acid content (Table 6).

The content of simple sugars was relatively low in tomatillo. Both tomato cultivars were superior in this respect (Table 1). However, the level of oligosaccharides in tomatillo was relatively high, whereas in tomato this class of sugars was almost absent (Table 1). Generally, tomatillo contained more total sugars than tomato. The ratio of total sugars to acids in tomatillo was variable – 6.25 in one year, and 11 in another (Table 1). As 'Rendidora B1' fruit approached ripeness (Table 2), the content of simple sugars slightly decreased and that of oligosaccharides rose markedly, resulting in a marked rise of total sugars when the fruit ripened. The ratio of total sugars to acids also increased (Table 2). This increase of total sugars during ripening does not always take place (see further text concerning cv. Bujna).

Table 6

Comparison of the chemical composition of the fruit of three cultivars of tomatillo. Fruit collected on 30.09.1986

Constituents	'Rendidora B1'	'Bujna'	'Antocyjanowa'
pH	4.01*	3.78*	3.73*
Dry matter (%)	7.8	8.9	9.6
Acids (%)	0.54	0.67	0.74
	0.70*	0.83*	0.93*
Simple sugars (%)	1.98	1.75	1.93
Oligosaccharides (%)	1.62	2.37	1.21
Total sugars (%)	3.60	4.12	3.24
Ratio: total sugars/acids	6.67	6.15	4.38

* Sample taken on August 26.

The comparison of three different cultivars of tomatillo (Table 6) showed that 'Bujna' has a highest level of total sugars, and 'Antocyjanowa' the lowest. On the other hand, 'Antocyjanowa' contained the highest amount of acid, whereas 'Rendidora B1' contained the lowest. The ratio of sugars to acids was very low in 'Antocyjanowa'.

The protein content in the dry mass was similar in tomato and tomatillo (Table 1) and did not change markedly during ripening (Table 2). The fat content in the dry mass of tomatillo fruit was rather high (8.7%).

The content of pectic substances in both investigated years, was similar to that of tomato (Table 7); nevertheless, the contribution of particular fractions was different. In tomatillo the fractions, water-soluble and ammonium

Table 7

Pectin content in tomatillo cv. Rendidora B1 and in tomato cv. Ostrawski Wczesny. Pectin expressed as galacturonic acid (in mg g^{-1} fresh matter)

	Fraction soluble in			Total
	water	ammonium oxalate	1N NaOH	
Tomatillo (collected 1987.08.12): Ripe (yellow)	0.74	0.58	1.75	3.07
Unripe (green)	0.79	0.50	2.39	3.68
Tomatillo (collected 1986.08.05)	0.58	0.69	2.05	3.31
Tomato (collected 1986.08.12)	1.31	1.80	0.38	3.55

oxalate-soluble, were relatively scarce, whereas, the fraction soluble in 1N NaOH was plentiful. In tomato, on the contrary, this last fraction was scarcely represented, while the two other occured in relatively large quantities.

Vitamin C content. It was characteristic that tomatillo showed very low levels of ascorbic acid (Table 8), only 1.10-1.80 mg $100g^{-1}$, but a much higher level of dehydroascorbic acid: 6.5-13.8 mg $100g^{-1}$. The sum of these two components represent 8.1-15 mg 100 g^{-1} vitamin C, depending on the date of harvesting and cultivar. The cultivar 'Rendidora B1' showed the highest vitamin C content and 'Bujna' – the lowest (Table 8). There was a tendency towards a decreased vitamin C level at the end of the vegetative season (Tables 8 and 9). The ripe fruit of 'Rendidora B1' showed in 1987, up to 21 mg 100 g^{-1} in July, and only 11.8 at the end of September. However, at each date of collection the ripe and unripe fruit did not differ markedly (Table 9).

Table 8

Vitamin C and its constituents (L-ascorbic and dehydroascorbic acids in mg 100 g^{-1} fresh matter) in three cultivars of tomatillo. Fruit collected in 1986

Cultivar	L-ascorbic acid		Dehydro-ascorbic acid		Vit. C	
	08.26	09.30	08.26	09.30	08.26	09.30
Rendidora B1	1.2	1.1	13.8	12.5	15.0	13.6
Bujna	1.8	1.6	7.2	6.5	9.0	8.1
Antocyjanowa	1.2	1.1	10.8	10.3	12.0	11.4

Table 9

The content of β caroten and of vitamins C and PP in unripe and ripe fruit of tomatillo cv. Rendidora B1. Collected on different dates in 1987

Date	Unripe fruit			Ripe fruit		
	β caroten	vit. C, mg 100 g^{-1}	vit. PP, mg 100 g^{-1}	β caroten	vit. C, mg 100 g^{-1}	vit. PP, mg 100 g^{-1}
07.17	–	21.0	0.80	–	21.0	0.80
09.10	–	17.0	–	–	18.0	–
09.28	0	8.6	1.03	0	11.8	1.30

The taste of the fresh fruit in relation to the content of acids and sugars was investigated in the populations (types) selected within the cultivar 'Bujna'. There was one type with good-tasting fruit, two with poor taste and one with very poor taste. We compared the content of particular acids and sugars in the fruit of these three types.

Good taste of ripe 'Bujna 3' fruit was correlated with the relatively high content of total sugars and high acid content (Table 10). High sugar and low acid content, as in 'Bujna 4', resulted in an insipid taste. The ratio of total sugars to acids was, however, not a good indicator of taste.

Table 10

The content of total non-volatile acids and total sugars (mg 100 g^{-1}) in the fruit of four types of tomatillo cv. Bujna differing in taste

Type	Taste of ripe fruits	Total non-volatile acids		Total sugars		Ratio of total sugars/acids	
		UR	R	UR	R	UR	R
2	mediocre	1325* c	829 a	4738 c	3833 b	3.57	4.62
3	very good	1166 b	1062 b	5202 d	5176 cd	4.46	4.87
4	insipid	1144 b	838 a	4256 bc	4838 cd	3.72	5.77
5	no tasty	1310 c	932 a	3064 a	3166 a	2.33	3.03

Unripe fruit contained more acids (significant differences occured even in 'Bujna 3' when 'Sd B(A)' was taken into account).

When particular non-volatile acids were considered, citrate (Table 11) was most abundant. Malate also appeared in significant amounts, but was 7.6-16 times less abundant than citric acid. There was also oxalate in quantities reaching 10-18 mg 100 g^{-1} in ripe fruit, and up to 53 mg 100 g^{-1} in unripe fruit (for comparison, in spinach, 1109 mg 100 g^{-1}, and in sweet pepper, 7.3 mg 100 g^{-1} – see Horbowicz 1984). Succinate occured in low concentrations 1-2 mg 100 g^{-1} (for comparison, in cabbage, 17.3, in lettuce, 43.3 and in patison, 27 mg 100 g^{-1} (see Horbowicz 1984)).

Table 11

Content of particular non-volatile acids (in mg 100 g^{-1}) in different types of tomatillo cv. Bujna

Type number	Citric		Malic	Oxalic	Succinic
2	UR	1169 D*	121.2 D	34.0 D	1.0
	R	801 A	13.8 A	12.5 AB	1.7
		(1.4)**	(8.8)	(2.72)	(0.58)
3	UR	983 BC	128.6 D	53.6 E	1.0
	R	1000 BC	42.2 B	18.3 B	1.9
		(0.98)	(3.0)	(2.92)	(0.53)
4	UR	1048 CD	64.8 C	29.9 C	1.4
	R	813 A	11.6 A	10.9 A	2.0
		(1.2)	(5.6)	(2.74)	(0.7)
5	UR	1124 CD	150.0 E	36.3 D	1.0
	R	894 AB	21.2 A	15.1 AB	1.5
		(1.3)	(7.1)	(2.40)	(0.66)
Average	UR	1081 N	116.1 N	38.4 N	1.1
	R	877 M	22.2 M	14.2 M	1.7

* The numbers marked in a column with the same letter do not differ significantly at P = 0.01.
UR – unripe fruit, R – ripe fruit.
** In paranthesis the ratio of the content of the given acid in unripe and ripe fruit.

The acid composition changed markedly during ripening. Malate decreased 3-9 times and oxalate decreased 2.4 to 3 times. The citric acid content decreased significantly (with the exception of 'Bujna 3') whereas the succinate content increased 1.4-2 times. The tastiest fruit (of 'Bujna 3') contained, when ripe, the highest content of citrate, malate and oxalate. It was characteristic of 'Bujna 3' fruit that the content of citric acid did not decrease during ripening.

Concerning particular sugars, fructose, glucose and saccharose were the only sugars detected in the fruit of tomatillo in significant amounts. It was characteristic that the content of the two simple sugars (fructose and glucose) decreased during ripening and saccharose increased (Table 12). The fruit of the tastiest type, 'Bujna 3', contained much more fructose than fruit of other types. The quantity of glucose was rather high in ripe 'Bujna 3' fruit, but the difference between 'Bujna 2' and 'Bujna 4' fruit was insignificant. The quantity of saccharose was higher in 'Bujna 3' than in 'Bujna 2' and 'Bujna 5' fruit, but lower than in 'Bujna 4' fruit. The content of total sugars in ripe 'Bujna 3' fruit was one of the highest, as already mentioned. In unripe fruit of 'Bujna 3' the content of total sugars was the highest (Table 10).

Table 12

Content of particular sugars in tomatillo (in mg 100 g^{-1})

Type number	Fructose			Glucose		Saccharose	
	UR	R	average	UR	R	UR	R
Bujna 2	990	640	815 B*	3240 D	1546 AB	508 B	1644 D
Bujna 3	1898	1408	1653 D	2990 D	1670 B	314 A	2098 E
Bujna 4	1202	860	1031 C	2310 C	1472 AB	744 C	2506 F
Bujna 5	460	342	401 A	1774 B	1188 A	830 C	1636 D
Average	1137 N	812 M		2578 N	1469 M	599 M	1971 N

* The numbers for a given compound marked with the same letter do not differ significantly at $P = 0.01$.
UR – unripe fruit, R – ripe fruit.

DISCUSSION

In general, our results agree with those of Souza-Novelo (1950) concerning those components which were investigated by us and by him, with the exception of iron content. The chemical characteristics of tomato and tomatillo fruit differ in several cases. Tomatillo has more dry matter and more extract than commonly cultivated tomato cultivars (compare Michalik et al. 1982).

High content of dry matter in tomatillo predisposes it to be good material for processing, Although tomatillo contains less potassium than tomato, this is compensated for by a tendency towards higher magnesium and iron contents. The content of Mg, Cu, Fe and Zn depended greatly, however, on the edaphic conditions and fertilization in a given year, which seems to be a normal phenomenon.

The unripe fruit of tomatillo contain a large proportion of fructose and glucose. As the fruit ripens the contents of these sugars decrease but the content of saccharose increases markedly. This probably results from a conversion of simple sugars into saccharose. This process does not occur on a significant scale in tomato (see Table 1).

A similar content of particular sugars as was found in the ripened fruit of tomatillo has also been found in melons (see Horbowicz 1984). An increase of total sugars as the fruit ripens is a common phenomenon among plants with flesh fruit (see Smock and Neubert 1950). However, in tomatillo the reverse process was often observed (Table 10). This may explain why, in Mexico, consumers prefer the unripe fruit in spite of its lower pH. Tomatillo fruit contains more acid than tomato; nevertheless, the acid taste does not dominate due to its relatively high sugar content. As in tomato, citric and malic acids were also most abundant in tomatillo (compare Horbowicz 1984). A relatively high content of oxalate is not a positive characteristic, but it can be noted that in spinach, which is considered a valuable vegetable, the content of oxalate is 60-100 times greater. The decrease of oxalic acid as the fruit is ripening may suggest that ripe tomatillo fruit is better for processing. A significant decrease of malate and oxalate must have a metabolic cause. A small decrease of citrate may results, at least partly, from dilution during increasing fresh matter of the fruit (when the synthesis of the compound has eventually ceased).

The correlation of good taste with the relatively high content of sugars and acids seems understandable; however, it is obvious that taste depends on many other compounds. Good taste of fresh fruit may not be wholly correlated with the good taste of processed products.

Vitamin C content in tomatillo is similar to that in popular cultivars of tomato (see Bąkowski and Borkowski 1969). Vitamin PP is somewhat higher in tomatillo, higher than in many other species and comparable to that of parsley leaves or savoy cabbage and potatoes.

A high content of pectin fraction soluble in 1N NaOH (protopectins) may be responsible for the mechanical resistance of tomatillo fruit.

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Wartość odżywcza owoców Miechunki pomidorowej (*Physalis ixocarpa* Brot.)

Streszczenie

Miechunka pomidorowa jest powszechnie uprawiana w Meksyku, lecz jest mało znana w innych krajach. Chemiczny skład owoców zebranych w polu był badany przez szereg lat. Miechunka pomidorowa zawierała stosunkowo dużo suchej masy (7-10%) i ekstraktu (6.6-7.4%).

Zawartość potasu w owocach była mniejsza w miechunce, niż w pomidorach uprawianych w tych samych warunkach. Zawartość żelaza była większa, a zawartość innych pierwiastków była podobna i zależna od warunków danego roku. Zawartość cukrów ogółem wynosiła 2.8 do 5.7%, zależnie od odmiany i typu hodowlanego. Procent glukozy i fruktozy zmniejszał się w owocach w czasie dojrzewania, a procent sacharozy wzrastał. Zawartość substancji pektynowych była podobna jak w pomidorze, ale stosunek poszczególnych frakcji pektyn był odmienny. Miechunka zawierała więcej kwasów niż pomidor i wykazała szczególnie dużą zawartość kwasów cytrynowego i jabłkowego. Zawartość kwasu jabłkowego zmniejszała sę bardzo znacznie w czasie dojrzewania. Zawartość kwasu szczawiowego wynosiła 11-18 mg 100 g^{-1} w dojrzałych owocach i do 54 mg 100 g^{-1} – w niedojrzałych. Witamina C występowała w ilości 8-21 mg 100 g^{-1} zależnie od odmiany i typu rośliny. Przeważał kwas dehydroaskorbinowy. Zawartość witaminy PP wynosiła 0.8-1.3 mg 100 g^{-1}.