

THE RESPONSE OF SEVERAL TOMATO CULTIVARS FOR PROCESSING IN CENTRAL TRANSYLVANIA CONDITIONS. II. FRUITS QUALITY

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Abstract. Nine tomato cultivars for fresh consumption and processing were evaluated for fruit quality at the Fruit Research Station Cluj-Napoca, Romania. The height of the fruits was between 46.7 mm (Red River) and 59.8 mm (Chico Grande), the diameter of the fruits oscillated between 48.0 mm (Event) and 72.4 mm (Natalia) and the form of the fruits was different from one variety to another: spherical for Indiana, high spherical for Chico Grande, Event, Jet, Montego and Line Cluj 8-2002, flattened spherical for Perla Clujului, Natalia and Red River. All the cultivars had fruits with firm flesh; the best firmness was represented by Chico Grande, Event and Line Cluj 8-2002, all these having been prescript as potential genitors for creation of the new varieties with a good firmness of the fruits. It was identified a strong correlation between the shape index and the firmness of the fruits ($r = 0.784$), which demonstrated that the high-spherical fruits had a more firm flesh than the flattened ones. The dry matter content of the fruits oscillated between 5.26% for Indiana and 8.25% for Natalia, these two varieties also providing the extreme limits for the sugar content: 4.58% (Indiana) and 6.25% (Natalia). The Mature Fruit Yield (MFY) was correlated in a strong and positive way to the dry matter content of the fruits and with their vitamin C content. Between the Total Fruit Yield (TFY) and the dry matter content of the fruits there was a positive correlation ($r = 0.843$). The weight of the fruits was significantly correlated to all the chemical traits of the fruits (the content of dry matter, ascorbic acid, sugar and titrable acids). The varieties obtained at Cluj-Napoca, Natalia and Perla Clujului, with fruits rich in sugar and in vitamin C were recommended as genitors in tomato breeding in order to create new cultivars with fruits proper for processing on a high level.

Key words: tomato, breeding, cultivars, fruits, quality, correlations

INTRODUCTION

For most of the modern varieties of tomatoes, the proportion of the dry matter of the fruits is between 5% and 7%. The dry matter of the fruits is made of 55% sugar, 12.5% acids, 13% solid insoluble alcohols, 11% ash and 6% other chemical components. The sugar (the glucose and the fructose) represents almost 75% of the total of the solid soluble substances. The acids (citric acid and malic acid) and the sugar induce in an essential way the taste of the fruits of tomatoes (Gould, 1983; Bletsos and Goulas, 2002; Susic et al., 2002; Ciofu et al., 2003; Stan et al., 2003). In the process of creation of the new varieties, it is quested to obtain cultivars with fruits rich in useful substances. This desideratum can be realized through conventional methods, in which the interspecific hybridization can be successfully used, even

if it has some disadvantages such as the long duration of time needed in order to recuperate the phenotype of the valuable parent (Sestraş, 2004). A growth from 5 to 7% of the dry matter content of the fruits has been realized through genetic engineering. Recent studies indicate the fact that each additional percentage of dry matter from the fruits of tomatoes “saves” about 70 million dollars from the processing costs every year (Sestraş and Jidavu, 2002; Jidavu et al., 2002).

MATERIALS AND METHODS

At the Fruit Research Station Cluj-Napoca (FRS Cluj-Napoca), in central Transylvania, Romania, a research was carried out to analyze the traits which provide the quality of the fruits in nine tomato cultivars for processing, studied over a period of three years (2003-2005). The studied cultivars were represented by: two varieties which were obtained at Cluj-Napoca (Perla Clujului and Natalia), three American varieties (Chico Grande, Indiana, Red River), three F₁ hybrids of Italian origin (Event, Jet, Montego) and a perspective Line (Cluj 8-2002) obtained at FRS Cluj-Napoca, the last one being in the testing process in order to be homologated. The chemical content of the fruits was determined in the biochemistry laboratory of FRS Cluj-Napoca.

RESULTS AND DISCUSSIONS

The main traits of the tomato cultivars for processing, studied in the three years of experiments (2003-2005) at FRS Cluj-Napoca are presented in Table 1.

Table 1

The main traits of fruits in nine tomato cultivars for processing,
FRS Cluj-Napoca, 2003-2005

Nr. crt.	Cultivars (Variants)	Fruit height (mm)	Fruit diameter (mm)	Index of fruit shape	The mark of fruits firmness*
1	Perla Clujului	52.7 ^o	63.3 ^{xxx}	0.83 ^{ooo}	8.3
2	Natalia	56.6 [˘]	72.4 ^{xxx}	0.78 ^{ooo}	8.2 ^o
3	Chico Grande	59.8 ^{xxx}	51.1 ^{ooo}	1.17 ^{xxx}	9.0 ^x
4	Indiana	52.3 ^{oo}	50.9 ^{ooo}	1.03 [˘]	8.2 ^o
5	Red River	46.7 ^{ooo}	49.8 ^{ooo}	0.94 ^{ooo}	8.5
6	Event F1	54.3 [˘]	48.0 ^{ooo}	1.13 ^{xxx}	9.0 ^x
7	Jet F1	55.7 [˘]	50.2 ^{ooo}	1.11 ^{xxx}	8.7
8	Montego F1	57.7 ^{xx}	52.5 ^o	1.10 ^{xx}	8.5
9	Cluj 8-2002	58.0 ^{xxx}	51.2 ^{ooo}	1.13 ^{xxx}	9.0 ^x
Mean of experiment (Control)		54.9	54.4	1.02	8.6

DL 5% = 1.8 1.5 0.04 0.4

DL 1% = 2.4 2.0 0.06 0.5

DL 0.1% = 3.1 2.5 0.08 0.7

*The appreciation was realised using a scale from 1 to 10 (1 = very low firmness; 10 = very high firmness).

The average height of the fruits from the studied cultivars fluctuated between 46.7 mm (Red River) and 59.8 mm (Chico Grande). The highest fruits were registered for the variety Chico Grande, Line Cluj 8-2002 and Montego Hybrid. Besides Red River, a low height of the fruits was also registered at Indiana and Perla Clujului.

The average diameter values of the fruits oscillated between 48.0 mm (Event) and 72.4

mm (Natalia). As a comparison to the average of the whole experiment (54.4 mm), the varieties that were created at Cluj, Perla Clujului and Natalia, had higher values, while the rest of the cultivars had significantly lower values.

The index of fruit shape was calculated as a proportion between the height and the diameter of the fruits and had different values for different varieties, even if the average for the whole experiment (which was of 1.02) was very close to the value of "1" which is characteristic for the spherical fruits. From the tested varieties, the most regular fruits, almost spherical, were identified in Indiana, with a value that was very close to the value of the experiment (1.03). The high-spherical fruits were represented by Chico Grande, but also by Event, Jet, Montego, Line Cluj 8-2002. The most flatten fruits (flatten spherical) were obtained from the following varieties: Perla Clujului, Natalia and Red River.

The firmness of the fruits, appreciated on a scale from 1 to 10, was good and very good, the obtained average values being between 8.2 and 9.0. As a result, all the cultivars have firm flesh, which is a very important desideratum for the consumption tomatoes (as fresh fruits) as well as for the processing tomatoes. The lowest firmness of the fruits was registered at Natalia and Indiana and a very high firmness was registered at Chico Grande, Event and Line Cluj 8-2002. The last cultivars were recommended as potential genitors in new breeding program, in order to create some new genotypes with fruits with a good firmness.

The values of the correlation coefficient of the main elements, which bring to the commercial aspect of the fruits (height, diameter and index of fruit shape) are presented in Table 2.

Table 2

The correlation coefficient (r) of the main traits of the fruits, in nine tomato cultivars for processing, studied at FRS Cluj-Napoca, 2003-2005

Correlated traits	Fruit Diameter	Fruit Index	Fruit Firmness
Fruit Height	0.105	0.444	0.417
Fruit Diameter		-0.843 ^{oo}	-0.605
Fruit Index			0.784 ^{xx}

r 5% = 0.632; r 1% = 0.765; r 0.1 % = 0.872

These data accentuate the strong negative correlation between the diameter of the fruits and the index of fruit shape, as well as the strong positive correlation between the index of fruit shape and the firmness of the fruit. It is likely, that the first correlation was expected, because the fruit index is in proportion to the fruit diameter (even if in the experiment, FI is not significantly correlated with the height of the fruits). Surprisingly, there is a strong correlation between the fruit index and the firmness of the fruit ($r = + 0.784^{**}$), which shows that high-spherical fruits have a more firm flesh. This assessment is sustained by the fact that the value of the correlation coefficient between the fruit diameter and the firmness of the fruit, even if it is not statistically assured ($r = - 0.605$), is quite high and very close to the limit for P 5% (0.632).

More than that, as apposed to the positive value of "r" between the index of fruit shape and the firmness of the fruit, the "r" between the fruit diameter and the firmness of the fruit is negative and it expresses the fact that the lower the firmness of the fruit is, the higher the diameter of the fruit.

Most of all, the varieties created at FRS Cluj-Napoca, Natalia and Perla Clujului were remarked for their content in dry matter (Table 3). Both of the varieties can be recommended as genitors for the improvement studies, in order to create new cultivars with fruits that fit industrial processing. For all the nine cultivars, the average of the experiment was of 6.62 %

and the extreme values were registered in Indiana (5.26 %) and Natalia (8.25 %).

In the experiment, the total sugar content oscillated between 4.58 % (Indiana) and 6.25 % (Natalia), and the average of the experiment was of 5.11%. Because, in the objectives of the tomato processing, the sugar content of the fruit is very advantageous. Both Natalia and Chico Grande have significant values, which are superior to the average of the experiment.

The highest content in titrable acids was registered for Perla Clujului and Natalia, while Indiana, Jet, Event and Cluj 8-2002 had the poorest levels.

Table 3

The synthesis of the results for the main chemical components of the fruits,
FRS Cluj-Napoca, 2003-2005*

Nr. crt.	Cultivars (Variants)	Dry matter (%)	Sugar (%)	Titrable acidity (%)	Ascorbic acid (mg)
1	Perla Clujului	7.98 ^{xxx}	5.13	0.76 ^{xx}	33.9 ^{xxx}
2	Natalia	8.25 ^{xxx}	6.25 ^{xxx}	0.56 ^x	37.7 ^{xxx}
3	Chico Grande	6.27	5.79 ^{xxx}	0.44	26.9 ^{oo}
4	Indiana	5.26 ^{ooo}	4.58 ^{ooo}	0.36 ^o	22.9 ^{ooo}
5	Red River	5.56 ^{ooo}	4.26 ^{ooo}	0.42	27.1 ^{oo}
6	Event F1	6.83	5.19	0.38	29.7
7	Jet F1	6.33	4.76 ^{oo}	0.36 ^o	28.9
8	Montego F1	6.27	4.89	0.46	29.5
9	Cluj 8-2002	6.86	5.13	0.38	29.1
Mean of experiment (Control)		6.62	5.11	0.46	29.5

DL 5% =	0.49	0.26	0.10	1.7
DL 1% =	0.65	0.35	0.13	2.3
DL 0.1% =	0.85	0.46	0.17	3.0

*The differences between the variants and the average of the experiment are showed through the significances of the interaction between variants and years.

Table 4

The correlations between the main chemical components of the fruits and the yields registered at the cultivars from experiment, FRS Cluj-Napoca, 2003-2005

Correlated traits	Value „r” calculated	Significance	Value „r” theoretical
Early Fruit Yield - Dry matter	-0.079	-	r5%: 0.632 r1%: 0.765 r0.1%: 0.872
Early Fruit Yield - Sugar	0.176	-	
Early Fruit Yield - Titrable acidity	-0.493	-	
Early Fruit Yield - Ascorbic acid	0.025	-	
Mature Fruit Yield - Dry matter	0.679	x	
Mature Fruit Yield - Sugar	0.447	-	
Mature Fruit Yield - Titrable acidity	0.180	-	
Mature Fruit Yield - Ascorbic acid	0.691	x	
Total Fruit Yield - Dry matter	0.843	xx	
Total Fruit Yield - Sugar	0.562	-	
Total Fruit Yield - Titrable acidity	0.464	-	
Total Fruit Yield - Ascorbic acid	0.025	-	
Fruit weight - Dry matter	0.818	xx	
Fruit weight - Sugar	0.676	x	
Fruit weight - Titrable acidity	0.757	x	
Fruit weight - Ascorbic acid	0.828	xx	

The varieties Perla Clujului and Natalia had fruits, which were richer in vitamin C, and

the varieties Chico Grande, Indiana and Red River registered differences, which were inferior to the average of the experiment (29.5 mg).

From the Table number 4, one can realise that the Mature Fruit Yield (MFY), which is represented by all ripen fruits harvested during the whole period, including the fruits cropped until 10th August of each experimental year, was strongly and positively correlated with the dry matter content of the fruits (+0.679*) and also with their vitamin C content (+0.691*).

The strongest correlation ($r = 0.843^{**}$) was realised between the Total Fruit Yield (TFY) and the dry matter content of the fruits.

It was considered interesting the fact that the fruit weight was strongly correlated with all the chemical traits of the fruits because there were identified significant correlations between the fruit weight and their content of dry matter, ascorbic acid, sugar and of titrable acids. Similar studies were also realised by Markovic et al. (1997, 2002), Helyes et al. (2003), Susic et al. (2002) etc. Markovic et al. (1997) identified negative correlations between the fruit weight and their content in dry matter.

There were identified strong and positive correlations between the chemical traits of the fruits of the cultivars in the experiment (Table 5). The “r” value was insignificant only between the content of sugar and the titrable acids content of the fruits.

Table 5

The correlations between the main chemical traits of the fruits from the cultivars in the experiment, FRS Cluj-Napoca, 2003-2005

Correlated traits		Fruits content in:		
		Sugar	Titrable acidity	Ascorbic acid
Fruit content in:	Dry matter	0.720 ^x	0.727 ^x	0.948 ^{xxx}
	Sugar		0.354 ^r	0.653 ^x
	Titrable acidity			0.689 ^x

$$r \ 5\% = 0.632; r \ 1\% = 0.765; r \ 0.1\% = 0.872$$

In the experiment, the higher the dry matter content of the fruits was, the higher was the fruits content of total sugar, titrable acids and ascorbic acid. In the same way, the fruits content of vitamin C grew along with the fruits content of total sugar and titrable acidity.

Besides the special character of the correlations, which have been identified in the experiment, which has a very important theoretical significance, the connections between these characters can also have a practical importance.

These could be applied as indicators, which could be used for the indirect assessment of the fruits chemical composition divided in elements, which are important for the alimentary and nutritive value of the tomatoes. Eventually, these indicators could be used to apply and to control the culture factors in order to obtain efficient harvests, efficient from an economical point of view and efficient for the consumer’s health, too.

In tomato breeding, the strong correlations between the traits can be successfully used in order to create new cultivars; these could be used as selection indices.

CONCLUSIONS

Considering the tomato cultivars for processing which were tested at Fruit Research Station Cluj-Napoca, important differences were obtained from the point of view of the quality characteristics of the fruits. The height of the fruits was between 46.7 mm (Red River)

and 59.8 mm (Chico Grande), while the diameter of the fruits oscillated between 48.0 mm (Event) and 72.4 mm (Natalia). Some of the varieties had spherical fruits (Indiana), others high spherical fruits (Chico Grande, Event, Jet, Montego and Line Cluj 8-2002) or flattened, flattened spherical fruits (Perla Clujului, Natalia și Red River).

All the cultivars had fruits with firm flesh, which is a very important desideratum for the fresh consumption tomatoes as well as for the processing tomatoes. The best firmness was obtained with the fruits from Chico Grande, Event and Line Cluj 8-2002, these ones being recommended as potential genitors for the new improvement studies. The aim is to create new genotypes of fruits with a very good firmness. A strong correlation was identified between the index of fruit shape and its firmness ($r = + 0.784^{**}$), which outlined the fact that high-spherical fruits had a more firm flesh than the flattened ones.

The dry matter content of the fruits had the extreme values in Indiana (5.26 %) and Natalia (8.25 %), the same varieties provided the extreme limits for the sugar content: 4.58 % (Indiana) and 6.25 % (Natalia).

The Mature Fruit Yield (MFY) was positively and strongly correlated with the dry matter content of the fruits and with their vitamin C content. Between the Mature Fruit Yield (MFY) and the dry matter content of the fruits there was a positive correlation ($r = 0.843^{**}$). The weight of the fruits was strongly correlated with all the chemical traits of the fruits (the content of dry matter, ascorbic acid, sugar and titrable acids).

The varieties Natalia and Perla Clujului, obtained at Cluj-Napoca have fruits rich in sugar and vitamin C. They have been recommended as genitors in breeding program in order to create new cultivars with proper fruits for a high level of the processing.

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REZUMAT

COMPORTAREA UNOR CULTIVARURI DE TOMATE PENTRU INDUSTRIALIZARE ÎN CONDIȚIILE DIN CENTRUL TRANSILVANIEI. I. CALITATEA FRUCTELOR

Între nouă cultivaruri de tomate pentru industrializare testate la Stațiunea de Cercetare Dezvoltare pentru Pomicultură Cluj-Napoca au fost înregistrate diferențe notabile pentru elementele de calitate ale fructelor. Înălțimea fructelor a fost cuprinsă între 46,7 mm (Red River) și 59,8 mm (Chico Grande), diametrul fructelor a oscilat între 48,0 mm (Event) și 72,4 mm (Natalia), iar forma fructelor a diferit de la un soi la altul: sferică la Indiana, sferic înaltă la Chico Grande, Event, Jet, Montego și linia Cluj 8-2002, sferic turtită (aplatizată) la Perla Clujului, Natalia și Red River. Toate cultivarurile au avut fructe cu pulpa fermă, deziderat foarte important atât la tomatele pentru consum în stare proaspătă cât și la cele pentru industrializare. Cea mai bună fermitate a fructelor au prezentat Chico Grande, Event și linia Cluj 8-2002, acestea fiind recomandate ca potențiali genitori pentru crearea unor soiuri noi, cu foarte bună fermitate a fructelor. S-a identificat o corelație strânsă între indicele de formă și fermitatea fructului ($r = + 0,784^{**}$), care a ilustrat faptul că fructele sferic-înalte (ovale sau alungite) au pulpa mai fermă comparativ cu fructele aplatizate. Conținutul fructelor în substanță uscată a oscilat între 5,26% la Indiana și 8,25% la Natalia, aceleași soiuri având limite extreme și pentru conținutul în zahăr: 4,58 % (Indiana) și 6,25 % (Natalia). Producția de fructe coapte a fost corelată pozitiv și strâns cu conținutul fructelor în substanță uscată și cu conținutul fructelor în vitamina C, iar între producția totală și conținutul fructelor în substanță uscată s-a înregistrat o legătură strânsă, pozitivă ($r = 0,843^{**}$). Greutatea fructelor a fost strâns corelată cu toate componentele chimice ale fructelor (conținutul în substanță uscată, acid ascorbic, zahăr și aciditate titrabilă). Soiurile obținute la Cluj-Napoca, Natalia și Perla Clujului, cu fructe bogate în zahăr și vitamina C, au fost recomandate ca genitori în lucrările de ameliorare, pentru crearea unor noi cultivaruri cu fructe pretabile la un nivel ridicat pentru procesare industrială.