Identification Organoleptic and Functional Quality Profiles in Spanish Traditional Varieties of Tomato

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Abstract

Despite the increasing importance of internal quality in breeding programmes and marketing of tomato, little information is available regarding organoleptic and functional profiles of traditional varieties of renowned quality. This is the objective of this work, consisting in the evaluation of internal quality of 51 traditional tomato accessions representative of the Spanish variability. Contents of total soluble solids, oxalic, malic, citric and glutamic acids, fructose, glucose and sucrose, vitamin C and lycopene were determined, obtaining the respective organoleptic and functional profiles. These profiles will be very valuable to establish breeding objectives, as these varieties are considerably appreciated by consumers, who are willing to pay higher prices for them. A considerably high level of variability has been found in the profiles obtained and no clear groups could be identified considering fruit morphology or local name. Variability was higher in traits affecting functional quality (coefficients of variation of 51.2% for vitamin C and 74.6% for lycopene content) than those affecting organoleptic quality (coefficients of variation ranging from 18% for total soluble contents to 38.8% for glutamic acid). Additionally, several accessions could be selected for their higher individual contents for further studies of internal quality. It is the case of accessions CDP8102 and CDP3547 for their high malic content, accession CDP6315 for high fructose and glucose contents, accession CDP1523 for its lycopene content and accessions CDP2226 and CDP336 for vitamin C content. Considering previous correlations among individual contents and consumer preference accessions CDP7554, CDP2666 and CDP3547 should be further evaluated for their overall flavour quality.

INTRODUCTION

For a long time, the quality of vegetables has been based only on their external appearance. This limited definition of quality was due to the marketing strategies of large distribution firms. Such strategies were focused on the visual impact of products. Nowadays, consumers require products with higher internal quality. Therefore, addressing different aspects of internal quality, such as organoleptic and functional qualities, is a main objective. In this context, traditional varieties play an important role as potential germplasm for breeding programs given their well-known internal quality and their high variability.

MATERIALS AND METHODS

Vegetal Material

A total of 51 entries of traditional varieties of tomato (*Solanum lycopersicon*), provided by the COMAV germplasm bank were studied (table 1). The seedbed was sown in April and was transplanted to a definitive field in May.

The crop was conducted in a field located in Turis (Valencia, Spain). A randomized complete block design was used with four blocks, one plot per accession and 3 plants per plot. The crop was managed using the usual practices for tomato cultivation in the area including drip fertirrigation.

Analytical Data

1. Sample obtention and preparation. The fruits were harvested at the mature-red stage. Samples were composed of a mix of two representative fruits of each of the 12 plants per accession. In the laboratory, equivalent longitudinal portions for each fruit were obtained, They were ground and homogeneized. Samples were kept frozen at -80ºC until analysis.

2. Quantification of the soluble solids content. The soluble solids content (SSC) was estimated by refractometry of the juice (average of two determinations) using a digital refractometer (ATAGO PR-1, Tokyo, Japan) with 0,1º Brix precission. The results were reported as º Brix at 20ºC.

3. Sugar and acid quantification. A modification of the method described by Roselló *et al.,* (2002) was used. This method is based on zone capillar electrophoresis and enables simultaneous quantification of oxalic, malic, glutamic, and citric acids and fructose, glucose, and sucrose sugars. A P/ACE MDQ capillar electrophoresis equipment was used for the analysis with the PA P/ACE MDQ Versión 2,3 software for Windows (Beckman Instruments Inc., Fullerton, CA. EE.UU.). A 50µm internal diameter and 363µm external diameter capillar of melted silice (Polymicro Technologies, Phoenix, AZ., EE.UU.) with total length of 67cm and 60cm of effective length was used for the separations.

The concentration of each item was computed using linear regressions using 5 solutions with variable concentrations of each component. The determination coefficitent was larger than 0.99 in all cases. Each sample was analyzed twice. The results were reported in percentage of fresh weight (g/100 g juice).

4. L-ascobic acid quantification. The method described by Galiana-Balaguer *et al.,* (2001) was used. This protocol, based on capillary electrophoresis, uses a 50µm internal diameter and 363µm external diameter capillar of melted silice (Polymicro Technologies) with total length of 27cm and 20cm of effective length for the separations.

The concentration was computed using linear regressions using 5 solutions with variable concentrations of L-ascorbic acid. The coefficient of determination was larger than 0.99. Each sample was analyzed twice. The average of the values obtained in all blocks were reported. The results were expressed as mg per 100g of fresh weight.

5. Lycopene quantification. The method reported by García-Plazaola and Becerril (1999) based on high performance liquid cromotography (HPLC) of reverse phase with stlight modifications was used. Analyses were carried out on a *1200 series* cromatographer (Agilent Technologies, Santa Clara, US). The cromatography was conducted in a column of reverse phase Tracer Spherisorb ODS-1 (250 x 4.6 mm i.d., 5 µm, particle size) protected by a guard column (20 x 3.9 mm i.d., 4 µm). The integration of the lycopene peaks was conducted at 470 nm. Sudan I was used as internal standard.

Lycopene concentration was obtained using linear regressions using 5 concentrations of known pattern. Always were obtained a 99.9% of coefficient of determination. Each sample was analyzed twice. The results were reported as ppm of fresh weight.

RESULTS AND DISCUSSION

Accession segregation was observed in several cases. Accession CDP8106, initially of pepper type, presented segregation. Although the pepper type (CDP8106(1)) was the main one, 4 plants of rounded morphotype (CDP8106(2)) were obtained. The accession CDP3947 also segregated generating 3 types: CD2226, with original morphotype, CDP1523 with round non-ribbed fruits, and CDP3947 with rounded ribbed fruits. This segregation is usual when working with original seeds, since farmers can provide mixed seeds or there may be a previous spontaneous hybridization and has been reviewed for other crops (Zeven, 2000).

A relevant content of oxalic acid was only obtained in four accessions: CDP7444, CDP6438, CDP3971(1) and CDP7499 (data not shown). This is a positive result since the oxalic acid is an antinutrient (Güil *et al.*, 1996) and its relevance for total acidity and pH is almost negligible. The results obtained on oxalic acid content were smaller than those reported (around 35mg/100g)for other traditional varieties (Cebolla Cornejo *et al.*. 2005).

Sucrose was only detected (97,4mg/100g) in accession CDP2714. The absence of sucrose accumulation is a standard feature of tomatoes given that the sucrose is hidrolized during the rippening process. However, sucrose traces have been obtained in some tomato varieties. In these, the concentration is always below 0.1% of fresh weight (Davies y Hobson, 1981), as in this case.

A large intervarietal variation for the remaining compounds was obtained. This variability was studied using principal component analysis. The oxalic and sucrose contents were not included considering their lack of variation. The two first components, which account for 70.5% of the total variation, were selected and plotted. The first component (56.1%) was positively correlated with the content of all the evaluated variables. Therefore, the accessions with a large first component may be especially interesting. The second component (14.4%) was positively correlated with the content of malic acid, glutamic acid, and fructose and negatively correlated with the content of citric acid, glucose and SSC.

The materials were irregularly distributed which made it difficult to identify specific groups (fig. 1). Out of this continuum of variation, only the accession CDP3547 was more isolated, with outstanding contents of most compounds.

In those few cases in which several accessions of the same variety were included (such as Moruno, Morado, Negro or Cuarenteno), they did not group themselves jointly. This seems to confirm the existence of a large intravarietal variability. It is not surprising that accessions of the same variety show different quality profiles given that traditional varieties are in fact population varieties. Nevertheless, the intravarietal evaluation is beyond the scope of this paper.

Since the 70s, researchers have focused on establishing correlations between analytical variables related with organoleptic quality and acceptability or preference order in tasting trials. There are several studies relating the content in soluble solids, total acidity, content in sugars, acids, and their relationships with acceptability or preference of some tomato varieties (Stevens, 1972; Stevens *et al.*, 1979; Davies and Hobson, 1981; Jones and Scott, 1984; Malundo *et al.*, 1995; Bucheli *et al.*, 1999a). Koehler and Kays (1991) established the correlation between sugars and the sweetness.

This relationship was also studied by other researchers (Baldwin *et al.*, 1998; Saliba-Colombani *et al.*, 1999). But the preference order in tasting trials seems to be more influenced by the relationship between sugars and acids than by the content in sugars (Baldwin *et al.*, 1998). The highly valued samples were, however, those with higher sugar content as described by Malundo *et al.* (1995) and Bucheli *et al.* (1999a). Additionally, using traditional varieties the model that best captured the preference order of a tasting panel was one based on relating the content in sugars (measured as sucrose equivalents) and the sugars to citric acid ratio (ATC) (Cebolla-Cornejo, 2005). Considering all these relations, it would be interesting to detect the accessions standing out for their content in individual compounds, in order to combine them later in elite materials.

In this sense, the most relevant accessions considering their content in individual compounds (table 2) would be: accessions CDP3547 and CDP8102 because of their large content of malic acid (260.6 and 222.3 mg/100g respectively), accession CDP6315 with a high content of citric acid (580.2 mg/100g), accession CDP9909 due to its low content of glutamic acid (17 mg/100g), and accession CDP3547 because of its high content of fructose and glucose (2,852.1 and 1,733.0 mg/100g respectively). For glutamic acid it is interesting to select accessions with lower values given that a higher sugar:glutamic ratio has been related to better acceptance in tasting trials (Bucheli *et al.*, 1999b).

In terms of the content in compounds related with the functional quality (table 3), coefficients of variation (51.2% for vitamin C and 74.6% for lycopene content) were higher than those affecting organoleptic quality (ranging from 18% for total soluble content to 38.8% for glutamic acid), showing a wide range of variation to identify sources of variation for breeding programmes. Accessions CDP1523 and CDP7554 should be highlighted for their high values in lycopene (5.337 and 4.493mg/100g PF respectively), doubling the standard content in tomato. The values of ascorbic acid were not particularly high, being the highest content 27.54mg/100g PF in accession CDP336. Nevertheless, it would be interesting to study the intravarietal variability and the stability of the content in accessions CDP2226 and CDP336.

In conclusion, the quality profiles of a considerably high representation of Spanish diversity of traditional tomatoes have been obtained. These profiles might be a key to lay down objectives in new breeding projects or to promote *in situ* conservation. The results obtained have shown that there is a significant intravarietal and intervarietal variability, enabling selections in both components.

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Table 1. Origin and main characteristics of the accessions being evaluated

ACCESSIONS	LOCAL NAME	SITE OF COLLECTION	FRUIT SHAPE	ASSIGNED TYPE
CDP9909	Tomate del terreno	Álava	Flattened intermediate ribbed	A
CDP9583	Tomate gordo del pais	Vizcaya	Flattened slightly ribbed	A
CDP3001	Tomate del bueno	Vizcaya	Flattened slightly ribbed	A
CDP3287	Tomate de pardo	Huesca	Flattened/rounded slightly ribbed	A
CDP8473	Tomate caqui	Granada	Flattened slightly ribbed	A
CDP7635	Tomate de corazón	Huelva	Strongly flattened strong ribbed	B
CDP4688	Tomate de casco	Almería	Flattened intermediate ribbed	A
CDP5663	Tomate de San Pedro	Almería	Rounded slightly ribbed	C
CDP2666	Tomate cherry	Almería	Purple flattened absent ribbed	D
CDP3600	Tomate de colgar	Granada	Flattened slightly ribbed	E
CDP4551	Tomate de pera;calabacita	Málaga	Pepper-shaped slightly ribbed	F
CDP4811	Tomate forma pimiento	Málaga	Pepper-shaped slightly ribbed	F
CDP6098	Tomate de pan	Cádiz	Cherry non-ribbed	G
CDP276	Tomate de pera	Córdoba	Rounded/heart-shaped pink slightly ribbed	J
CDP9696	Tomate morado	Cádiz	Strongly flattened strong ribbed	B
CDP4237	Tomate negrito	Málaga	Flattened/rounded slightly ribbed	A
CDP3947	Tomate melillero	Málaga	Heart-shaped/rounded slightly ribbed	H
CDP9352	Tomate borondo	Jaén	Heart-shaped/rounded slightly ribbed	H
CDP3604	Tomate de Badajoz	Jaén	Heart-shaped/rounded slightly ribbed	H
CDP6169	Tomate valenciano	Granada	Slightly flattened slightly ribbed	A
CDP8106	Tomate pimiento largo	Córdoba	Pepper-shaped slightly ribbed	F
CDP3480	Tomate de Calzada	Asturias	Flattened/rounded slightly ribbed	A
CDP3547	Tomate negro	Sta. Cruz de Tenerife	Flattened/rounded slightly ribbed	A
CDP2714	Tomate criollo para mojo	Sta. Cruz de Tenerife	Flattened/rounded slightly ribbed	A
CDP5540	Tomate de Monserrat	Barcelona	Strongly flattened pink strong ribbeb	B
CDP3250	Tomate pometa	Barcelona	Flattened slightly ribbed	A
CDP6315	Tomate palo santo	Barcelona	Rounded slightly ribbed	C
CDP6043	Tomate rosa ple	Barcelona	Flattened slightly ribbed	A
CDP7554	Tomate montserrat	Barcelona	Strongly flattened intermediate ribbed	B
CDP7596	Tomate	Palencia	Rounded pink slightly ribbed	I
CDP8237	Tomate cuarenteno	Valencia	Rounded slightly ribbed	C
CDP2498	Tomate trunfera	Lleida	Flattened/rounded very slightly ribbed	A
CDP8443	Tomate moruno	Madrid	Flattened intermediate ribbed	A
CDP7718	Tomate casco duro	Cuenca	Strong flattened slightly ribbed	B
CDP1819	Tomate de pico	Cáceres	Heart-shaped slightly ribbed	J
CDP336	Tomate gordo rosa	Cáceres	Slightly flattened slightly ribbed	A
CDP4081	Tomate rosa de colgar	Cáceres	Slightly flattened slightly ribbed	A
CDP8000	Tomate	Pontevedra	Heart-shaped slightly ribbed	J
CDP771	Tomate morado	Ciudad Real	Strongly flattened pink slightly ribbed	B
CDP9005	Toledo moruno	Ciudad Real	Strongly flattened strong ribbed	B
CDP8737	Tomate flor de baladre	Murcia	Strongly flattened strong ribbed	A
CDP3971	Tomate de Guadalupe	Murcia	Flattened slightly ribbed	A
CDP524	Tomate muchamiel	Murcia	Flattened slightly ribbed	A
CDP6438	Tomate del pais	León	Rounded slightly ribbed	C
CDP9667	Tomate cuarenteno	Valencia	Flattened slightly ribbed	A
CDP7167	Tomate de San Juan	Alicante	Flattened/ rounded intermediate ribbed	C
CDP7499	Tomate cuarenteno	Valencia	Heart-shaped/rounded slightly ribbed	A
CDP720	Tomate valenciano	Valencia	Heart-shaped/rounded slightly ribbed	J
CDP68	Tomate raf	Alicante	Strongly flattened intermediate ribbed	B
CDP7444	T. casero de Aretxabaleta	Vizcaya	Strongly flattened slightly ribbed	B
CDP8102	Tomate corazon de moreno	Álava	Flattened/rounded intermediate ribbed	A

Table 2. Accessions with the highest values in compounds related to organoleptic quality.

ACCESSIONS	MALIC ACID (mg/100g FW)	ACCESSIONS	CITRIC ACID (mg/100g FW)	ACCESSIONS	GLUTAMIC ACID (mg/100g FW)
A-CDP3547	277,31	C-CDP6315	580,22	A-CDP9909	17,00
A-CDP8102	260,59	H-CDP3947(1)	473,20	C-CDP5663	46,92
B-CDP771	221,28	B-CDP7444	462,12	J-CDP8000	53,49
H-CDP3604	214,73	A-CDP3547	450,54	A-C-L-249	55,22
I-CDP7596	213,24	H-CDP3947	446,11	A-CDP6043	60,52

ACCESSIONS	FRUCTOSE (mg/100g FW)	ACCESSIONS	GLUCOSE (mg/100g FW)	ACCESSIONS	SSC (ºBrix)
A-CDP3547	2852,05	A-CDP3547	1723,02	F-CDP4811	5,9
I-CDP7596	2482,24	I-CDP7596	1335,46	A-CDP3001	5,7
C-CDP6315	2454,24	F-CDP4811	1251,59	A-CDP336	5,7
J-CDP720	2334,03	H-CDP3947	1195,85	B-CDP771	5,3
H-CDP3604	2285,81	A-CDP336	1169,15	H-CDP2226	5

Table 3. Lycopene and ascorbic acid contents.

ACCESSIONS	LICOPENE (mg/100g FW)	ASCORBIC ACID (mg/100g FW)	ACCESSIONS	LICOPENE (mg/100g FW)	ASCORBIC ACID (mg/100g FW)
CDP9909	2,158	6,83	CDP5540	0,530	16,62
CDP9583	0,602	21,69	CDP3250	1,654	16,72
CDP3001	2,518	21,39	CDP6315	1,506	19,49
CDP3287	1,351	22,17	CDP6043	1,456	15,51
CDP8473	2,179	0,96	CDP7554	4,493	n,d,
CDP7635	1,456	17,31	CDP2498	0,654	18,62
CDP4688	1,578	0,39	CDP7596	2,429	21,65
CDP5663	2,465	20,91	CDP8443	1,980	n,d,
CDP2666	0,620	n,d,	CDP7718	1,987	23,31
CDP3600	3,802	9,92	CDP8237	1,905	12,56
CDP4551	1,111	11,32	CDP1819	4,184	15,01
CDP4811	2,227	14,28	CDP336	3,000	27,54
CDP6098	2,393	5,31	CDP4081	3,706	17,04
CDP276	0,394	7,04	CDP8000	2,324	20,94
CDP9696	0,855	15,51	CDP771	1,627	17,54
CDP4237	1,099	13,45	CDP9005	1,547	19,97
CDP2226	1,780	26,67	CDP8737	0,478	22,38
CDP1523	5,337	n,d,	CDP3971	1,413	n,d,
CDP3947	4,000	6,49	CDP524	2,349	5,53
CDP9352	0,766	14,67	CDP6438	2,110	0,71
CDP3604	3,517	12,2	CDP9667	1,665	12,95
CDP6169	4,338	11,68	CDP7167	3,089	6,32
CDP8106(1)	3,335	20,78	CDP7499	2,175	8,84
CDP8106(2)	0,839	17,44	CDP720	1,250	13,13
CDP3480	2,951	n,d,	CDP68	2,224	3,89
CDP3547	0,432	0,94	CDP7444	0,647	9,55
CDP2714	3,584	8,14	CDP8102	0,768	8,68

Figure 1. Principal components analysis considering compounds related to organoleptic quality