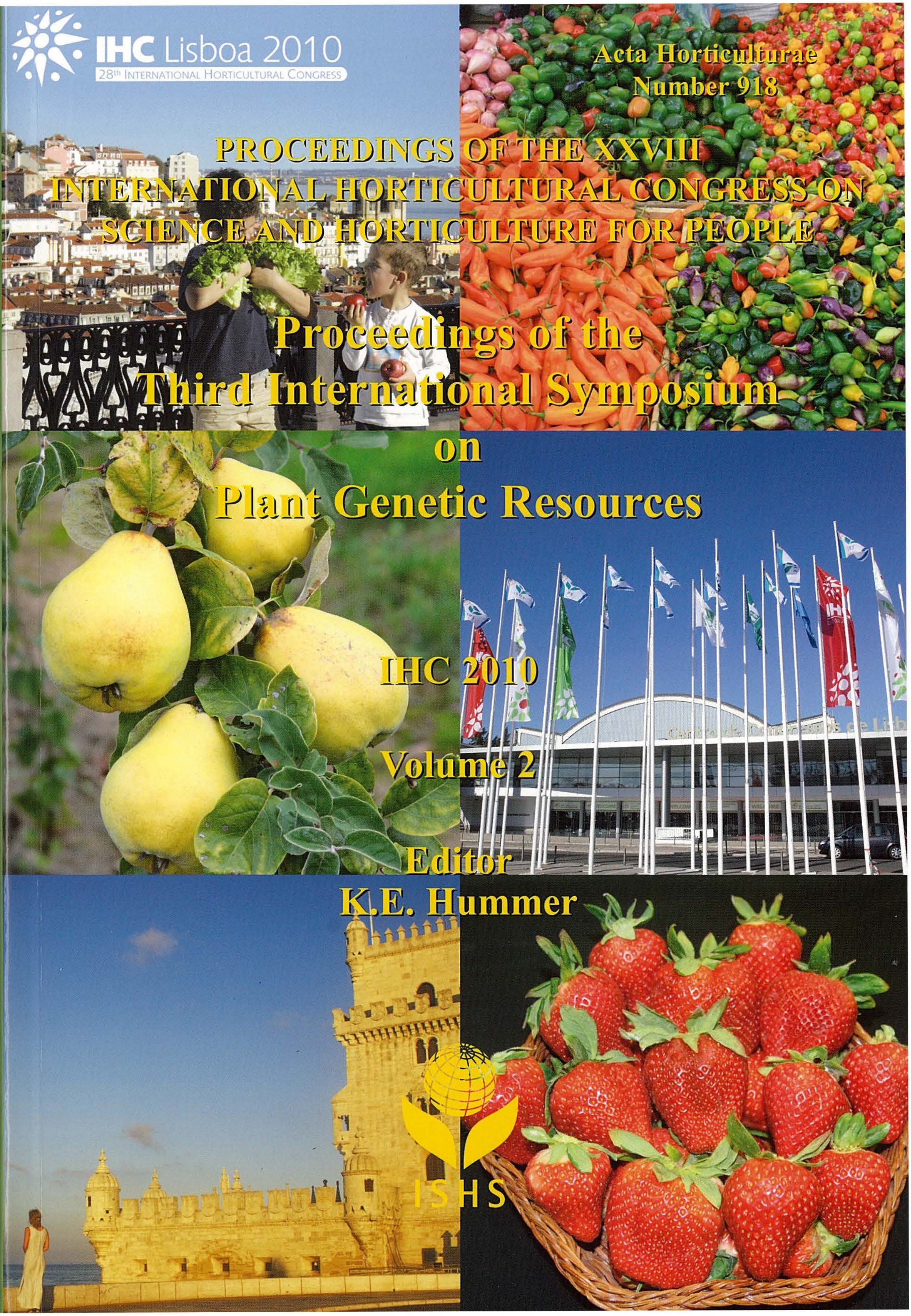

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1. Lisbon and the IHC2010.
2. Variability of pepper *(Capsicum)* in a local market in Peru (by courtesy of Femando Nuez, Universidad Politécnica de Valencia, Spain).
3. Quince *(Cydonia oblonga* L), an underutilized fruit resource (by courtesy of Joseph Postrnan, USDA ARS National Clona! Germplasm Repository, Corvallis, Oregon, USA).
4. Lisbon and the IHC2010.
5. Lisbon and the IHC2010.
6. Cultivated strawberry *(Fragaria* x *ananassa* Dusch.), an intemational fruit (by courtesy of Kim Hummer, USDA ARS National Clona! Germplasm Repository, Corvallis, Oregon, USA).

Screening a Diverse Collection of Heirloom Tomato Cultivars for Quality and Functional Attributes

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Keywords: biodiversity, antioxidant activity, polyphenols

Abstract

Fruits of cultivated tomato exhibit a high phenotypic diversity, having varied sizes, shapes and colours. This phenotypic variation is particularly apparent in beirloom cultivars. A set of cultivars, including many genotypes with fruit described as brown, black and purple were screened for quality and functional attributes. The collection includes mainly heirloom tomato cultivars obtained from TomatoFest (Little River, California, USA; http://www.tomatofest.com) and sorne traditional Spanish cultivars. Plants were grown in the open air, and their fruits were analyzed for colour, titratable acidity and soluble solids content (TSS). In a subset of the collection we have studied functional attributes, as the antioxidant activity and the polyphenols content. Wide variation was observed in each of the measurements. For example, the soluble solids content varied between 3.91 and 7.21 °Brix, and the titratable acidity between 0.49 and 1.07 g/100 g. Very high levels of diversity were also found for the functional attributes analyzed, the antioxidant activity varying between 7.90 and 56.82 mg/100 g and the polyphenols content between 26.73 and 43.17 mg/100 g. Data obtained have been analyzed for their mutual relationships. We observed significant correlations among polyphenols content and the titratable acidity, soluble solids content and anti-oxidant activity. These results could aid tomato breeders working on the development of new cultivars. The diversity found in heirloom tomato cultivars could be a rich source of germplasm for quality and functional attributes.

INTRODUCTION

Tomato *(Solanum lycopersicum* L.) is one of the most important crops in the world, with a crop area of more than 5 million ha, and an annual production of close to 130 million tons (FAO, 2010). Although cultivated tomato has a very narrow genetic base (Miller and Tanksley, 1990), there is a huge diversity of cultivars which greatly differ in characteristics such as shape, firmness, solid soluble contents, aroma and volatiles. For example, Gomez et al. (2001) found important differences for sorne colorimetric and physicochemical parameters among sorne closely related Spanish local cultivars, and Saha et al. (2010) have found significant variations for different nutritional, functional and textura! attributes among Indian local cultivars. Exploring natural biodiversity as a source of novel alleles to improve the productivity, adaptation, quality and nutritional value of crops is of prime importance (Femie et al., 2006). Continuous efforts have been made to improve the quality of grains and vegetable crops (Romer et al., 2000).

From a consumer's point of view, colour, total soluble solids (TSS) and titratable acidity (TA) are important components of flavour and quality of tomatoes (Baldwin et al., 2000). Tomatoes are very low in fat and calories, as well as being a good source of fibre. In addition, tomatoes are rich in carotenoids such as lycopene and ,8-carotene, vitamin C and other antioxidants, including total phenols (Mangels et al., 1993).

MATERIAL AND METHODS

A set of 39 cultivars obtained from Carmel TomatoFest (http://www.tomatofest.com), including many genotypes with fruit described as brown, black and purple were studied. One 'Muchamiel' traditional Spanish cultivar and the 'Boludo' F_1 cultivar were included as references (Table 1).

Ten plants of each cultivar were grown in an experimental field of the Miguel Hernández University in Orihuela, between March and July 2009. Plants were grown vertically with single stem, following the standard cultural practices for tomato crop in the SE of Spain.

Fruits were individually harvested at commercial ripening state. Six harvests were carried out at intervals of 7-10 days. Instrumental colour of whole tomatoes (expressed in CIE $L^*a^*b^*$ coordinates) was measured in triplicate in each tomato using a Minolta CR-300 colorimeter (Minolta Camera Co. Ltd., Osaka, Japan). Immediately after the fruit had been juiced, using a domestic juice extractor, the total soluble solids content (TSS) was estimated using an Atago PR-100 digital refractometer (Atago Co. Ltd., Tokyo, Japan); the results were expressed as °Brix. Titratable acidity (TA) was measured by titration with 0.1 N NaOH until pH 8.1 with a Crison pH matic 23; data were presented as g of citric acid per 100 g. These quality parameters were measured in fresh fruit, immediately after harvest.

For antioxidant activity (AA) and polyphenols content (PC) quantification, 4 g of tomato fruit (stored at -80°C) were homogenized in 10ml of 50 mM phosphate buffer, pH 7.8 and then centrifuged at 15000 rpm for 15 min at 4°C. The supernatant was used for AA and PC quantification, according to Cano et al. (1998) and Singleton et al. (1999), respectively. AA was expressed as mg of L-ascorbic acid equivalent to 100 g, and PC as mg of gallic acid equivalent to 100 g.

A complete randomized experiment design was adopted. To identify the significant differences between the cultivars, an analysis of variance was performed, using Statgraphics Plus. Newman-Keuls test was used for mean separation.

RESULTS AND DISCUSSION

Wide variations were observed in all of the measurements (Table 2), probably due to the wide genetic basis of the tested tomato genotypes. For example, the soluble solids content varied between 3.91 and 7.21 °Brix, and the titratable acidity between 0.49 and 1.07 g 100 g^{-1}. Similar variation ranges were obtained by Guillén et al. (2006) in commercial cultivars and Gómez et al. (2001) and Ruiz et al. (2005) in traditional cultivars. This result reflects the high genetic variability leve! that exists for these characters. Variation in colour attributes (Table 2) depended on the characteristics of the cultivars studied. The studied cultivars include accessions with ripe fruits of green, yellow, orange, pink, red, purple or brown colour. This great variability of colours is the result of selection performed by traditional farmers.

Very high levels of diversity were also found for the functional attributes analyzed (Table 2), varying the antioxidant activity between 7.90 and 56.82 mg/100 g and the polyphenols content between 26.73 and 43.17 mg/100 g. Wide variation ranges were also obtained by Saha et al. (2010) studying others functional attributes as lycopene, /3-carotene and ascorbic acid.

Parameters were correlated (Table 3). Soluble solids content and titratable acidity were highly correlated (r=0,999, P<0.01). Polyphenols content was correlated with soluble solids content (r=0,694, P<0.01), titratable acidity (r=0,687, P<0.01) and antioxidant activity (r=0,677, *P<0.05*). The L* colour component was negatively correlated with antioxidant activity (r=-0,615, *P<0.05)* and polyphenols content (r=-0,639, *P<0.05)*. Arnong the colour components, only L* and a* were negatively correlated (r=-0,852, P<0.01). Chaib et al. (2007) and Saha et al. (2010) also found significant correlation between several quality and functional attributes.

CONCLUSIONS

The different quality and functional attributes analyzed in a tomato collection including mainly heirloom tomato cultivars have shown a high variability. Nowadays, all these attributes have a growing importance for the consumer. The diversity found in heirloom tomato cultivars could be a rich source of germplasm for quality and functional attributes, therefore the results obtained could be useful for tomato breeders working on the development of new cultivars.

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Tables

Table 1. Name, type and origin ofthe accessions included in this study.

Accessions	Type and origin
Aunt Ginny's Purple, Aunt Ruby's, German Green, Black, Black Cherry, Black Crimson, Black Ethiopian, Black from Tula, Black Krim, Black Pear, Black Plum, Black Prince, Black Sea Man, Black Zebra, Blue Fruit, Carbon, Charlie's Green, Cherokee Chocolate, Cherokee Green, Cherokee Purple, Chocolate Stripes, Evergreen, Grandma Oliver's Green, Green Giant, Green Pineapple, Indische Fleish, Japanese Black Trifele, Mr. Brown, Nyagous, Paul Roberson, Pineapple, Purple Calabash, Red Pear, Southem Night, Spear's Tennessee Green, Super Snow White, Tim's Black Ruffles, White Queen and Brown Berry	Traditional cultivars or heirlooms from Carmel TomatoFest (http://www.tomatofest.com)
Boludo	F_1 hybrid from Seminis Seeds
Muchamiel 29	Traditional cultivar from EPSO germplasm bank

Table 2. Basic statistics for the properties ofthe tested tomato cultivars.

	Unit mean	SD	Minimum	Maximum	CV(¾)
Soluble solids	ºBrix	0.55	3.91	7.21	10.66
Titratable acidity	g 100 g^{-1}	0.15	0.49	1.07	22.03
Antioxidant activity	mg L-ascorbic acid 100 g^{-1}	6.95	7.90	56.82	21.02
Polyphenols content	mg gallic acid 100 g^{-1}	19.85	26.73	43.17	72.95
L*		12.34	36.95	102.49	0.23
a*		9.38	-6.01	25.76	76.2
b*		10.99	-3.28	48.12	41.4

Table 3. Correlation coefficients of quality and functional attributes.

	Titratable acidity	Antioxidant activity	Polyphenols content	L*	a*	b*
Soluble solids	0.999**	0.396	0.694**	-0.279	0.179	0.037
Titratable acidity		0.379	0.687**	-0.276	0.177	-0.056
Antioxidant activity			0.677*	-0.615*	0.551	0.074
Polyphenols content				-0.639*	0.483	0.107
L*					-0.852**	0.322
a*						-0.396

* $P<0.05$; ** $P<0.01$.