Influence of Ripening Stage on Quality Parameters of Five Traditional Tomato Varieties Grown under Organic Conditions

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Abstract: Consumers demand traditional, tasty tomatoes in contrast to new hybrid cultivars that have poor sensory characteristics. Some physicochemical parameters (total soluble solids, pH, titratable acidity, color and firmness), functional properties (vitamin C, lycopene, β-carotene and total antioxidant activity) and sensory characteristics of five traditional tomato varieties (T1-T5) in three ripening stages, grown under organic conditions, were evaluated. These were compared to the commercial hybrid 'Baghera', grown in the same conditions. Firmness of all varieties declined and the color parameters L* and H* decreased, whereas a* and a*/b* increased progressively with ripening. Lycopene also increased with ripening in all varieties, with the highest content being 132.64 mg kg^{-1} fw for T4. All traditional tomato varieties were richer in lycopene than commercial ones in the two last ripening stages. Vitamin C content ranged widely between 27.33 and 267.27 mg kg^{-1} fw. Among the traditional varieties, T2 (BGV003524) stood out due to its highest total soluble solids and vitamin C contents, total antioxidant activity, and H* and a*/b*; this variety was also the most appreciated by panelists. These traditional varieties could be an alternative to commercial cultivars, as they have good quality characteristics and can satisfy consumer demand for organic produce.

Keywords: antioxidant capacity; ascorbic acid; lycopene; organic production; *Solanum lycopersicum*

1. Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most widely cultivated vegetables both for fresh and processed produce. In 2020, tomato production for fresh consumption was 186.8 million tons in the world, of which 4.3 million tons were produced in Spain, which is the second largest producer in Europe after Italy [1]. Commercial hybrids are usually employed in this crop; one of these is the cultivar 'Baghera', that is widely cultivated in Spain due to its early production, medium-size, uniformly colored fruits and resistance to the main diseases of this crop.

The widespread consumption of tomatoes makes them a major source of health-related compounds [2]. Tomato antioxidants include vitamin C and carotenoids, such as lycopene and β-carotene. These antioxidants play an important role in protecting cells and cellular components against oxidative damage [3,4]. Lycopene is the carotenoid responsible for the red color in tomatoes [5], and accounts for more than 80% of the total carotenoids in ripe tomatoes [6]. The reported benefits of lycopene include prevention of degenerative diseases, such as certain types of cancer [7,8] and cardiovascular diseases [9,10]. Tomato antioxidant concentrations are related to genotype, but also to factors such as ripening stage, cultivation practices and climatic environment [11,12].

The most important external criterion to assess ripeness in tomato is color, which is directly related to the perception of quality. Tomatoes are usually consumed at their maximum organoleptic quality, i.e., when red color appears but before excessive softening occurs [13].

There is a growing interest in promoting the survival of traditional tomato varieties, as consumers find them more tasty and healthy [14,15]. Organic horticulture represents a sustainable and alternative agricultural model with the potential to provide both environmental improvements and high quality output [16]. In many regions, traditional landraces of tomato are still cultivated on a small scale for local consumption [17], and they are sold at higher prices than modern hybrids, as they are greatly appreciated by consumers [15,18,19]. It is necessary to characterize the quality and nutritional attributes of traditional tomato varieties, because only some phenotypic descriptors are available [20,21].

The aim of this work was to assess variations in the physicochemical parameters and bioactive compounds of five traditional tomato varieties, grown under organic conditions, in three ripening stages, and to compare these with the commercial hybrid 'Baghera' produced in the same conditions.

2. Materials and Methods

2.1. Plant Material

Tomato fruits were grown in open air under organic conditions in the south west of Spain, according to Spanish regulations, in one season. The study was carried out in an experimental field at the Scientific and Technological Research Center of Extremadura (CICYTEX) at an altitude of 217 m above sea level (38°51′ N; 6°40′ W). The climate is semi-temperate, with around 550 mm of rainfall and mild winters. The soil texture is sandy loam, pH 6.8, and low organic matter content. Plants of all cultivars were nursery produced and transplanted outdoors on the same date, in a randomized complete block design with three replications. The experimental unit was a plot of 15 m². Trellising was used to grow tomato plants that were pruned to a single stem.

The traditional tomato varieties studied were T1, T2, obtained from the Centre for the Conservation and Improvement of Agrodiversity (COMAV, Valencia, Spain), T3, T4, and T5 from the Institute of Agricultural and Food Research and Development (IMIDA, Murcia, Spain). The commercial hybrid used in this study was 'Baghera' from (Clause, Portes lès Valence, France) (Table 1, Figure 1). Tomato samples were picked in a single harvest and visually classified at three different ripening stages: turning (***turning***), light-red (***light-red***) and red (***red***), according to the color ripeness chart established by the United States Standards for Grades of Fresh Tomatoes [22]. Ten fruits per variety and ripening stage were randomly selected and analyzed in the laboratory for total soluble solids content (TSS), titratable acidity (TA), pH, firmness and color. Firstly, color and firmness measurements were performed on whole tomatoes, and then the fruits were homogenized for analysis of TSS, TA and pH. In addition, 10 fruits per variety and ripening stage were packed and stored at −80 °C for carotenoids, vitamin C, and total antioxidant activity (TAA) analyses. Finally, a sensory evaluation was carried out with tomato samples in the ***light-red*** stage.

Table 1. Sources, origins and fruit type of the studied varieties.

Variety	Code	Source	Origin	Local Name [1]	Fruit Type [2]
BGV001000	T1	COMAV	Granada	Tomate del país	2 */3 **
BGV003524	T2	COMAV	León	–	5/1
MUL15	T3	IMIDA	Murcia	Tomate de pera	4/1
MUL24	T4	IMIDA	Murcia	Tomate murciano	2/1
MUL36	T5	IMIDA	Murcia	Tomate murciano	3/1
Baghera F1	Baghera	Commercial hybrid	Clause (France)	–	2/1

[1] –: Without local name. [2] Descriptors for tomato: * "Predominant fruit shape" (7.2.2.5) / ** "Fruit cross-sectional shape" (7.2.2.29), according to IPGRI [23].
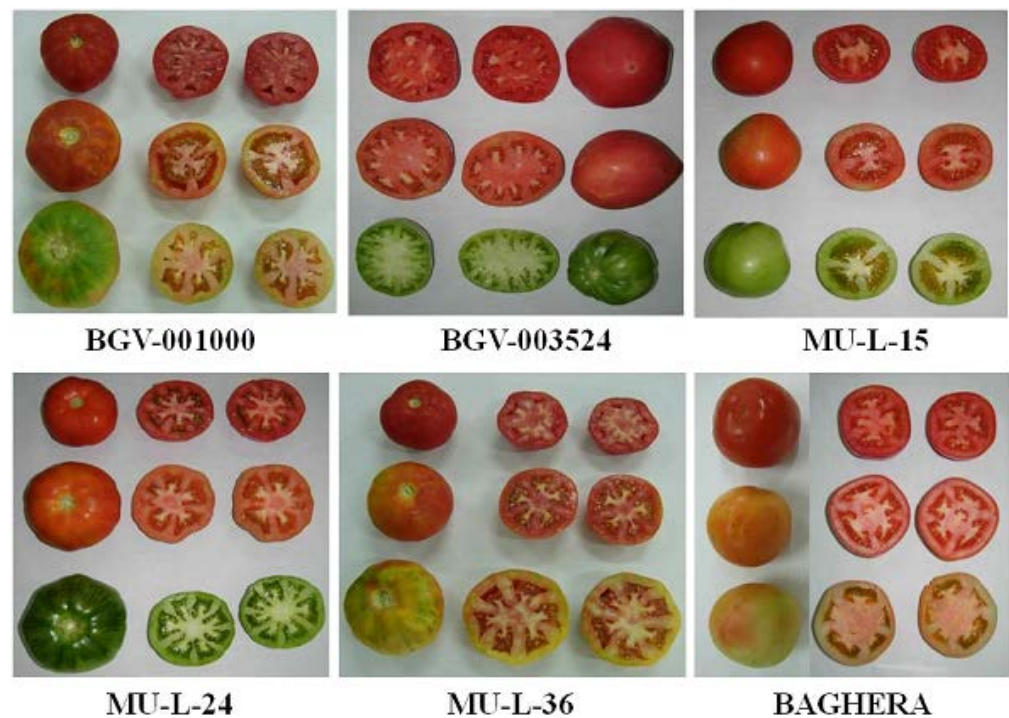
Figure 1. Traditional varieties and commercial hybrid: BGV001000 (T1), BGV003524 (T2), MUL15 (T3), MUL24 (T4), MUL36 (T5) and 'Baghera' F1 (Baghera).

2.2. Total Soluble Solids, Titratable Acidity and pH

Tomato fruits were divided into four groups and homogenized using a Thermomix 31–1 (Vorwerk España M.S.L., S.C Madrid, Spain). Total soluble solids (TSS) were determined with a digital refractometer (Mettler-Toledo S.A.E., Barcelona, Spain) and the results were expressed as °Brix. Tritatable acidity (TA) was assayed by automatic titration with 0.1 N sodium hydroxide up to pH 8.1 with a DL50 Graphix automatic titrator (Mettler-Toledo S.A.E., Barcelona, Spain) and expressed as g citric acid 100 g^{-1}. In addition, for each variety, Acceptability or Maturity Index (AI = TSS/TA) and Flavor Index (FI = (TSS/(20 × TA)) + TA) were calculated [24].

2.2.1. Firmness

For each variety and ripening stage, firmness was evaluated on ten fruits by a compression test using a TA.XT2i Texture Analyzer (Aname, S.L., Madrid, Spain). Measurements were taken at two opposite points on the equator of each fruit with a plane compression plate (100 mm diameter), a speed of 2 mm s^{-1} and a fruit deformation of 2%. Maximum force (N) and slope of the force/deformation curve (N mm^{-1}) were registered.

2.2.2. Color

Color measurements were performed on the surface of ten tomatoes per variety and ripening stage with a Konica Minolta CM-3500d Spectrophotometer (Aquateknica, S.A., Valencia, Spain). Reflectance measurements were made with the primary illuminant D65 and a circular measurement area of 30 mm diameter. Color readings were taken on two different positions of the equatorial region of each fruit. The CIEL*a*b* parameters were directly obtained and then Hue angle (H* = $\tan^{-1}$ (b*/a*)), Chroma (C* = $(a^{*2} + b^{*2})^{1/2}$) and a*/b* ratio were calculated.

2.2.3. Carotenoids

Lycopene and β-carotene were determined by HPLC, according to the method described by Sabio et al. [25] in an Agilent 1100 HPLC chromatograph (Agilent Technologies, Inc., Palo Alto, CA, USA) with an Agilent LiChrosorb RP-18 4.6 × 200 mm–10 μm column

maintained at 30 °C and after extraction with acetone: ethanol: hexane. The flow rate was 1 mL min^{-1}, peaks were detected by DAD at 460 nm and quantification was carried out using lycopene and β-carotene standards solutions. Extractions were carried out in triplicate and the results were expressed as mg kg^{-1} fw.

2.2.4. Vitamin C

Vitamin C was assessed as ascorbic acid (AA) by HPLC with UV detection according to González-Cebrino et al. [16]. Fruits were sliced and homogenized using a domestic blender, and then mixed and extracted with EDTA/metaphosphoric solution (85%) on ice for 1 min (Omni Mixer Homogenizer, Omni International, Kennesaw, GA, USA). The extracted sample was filtered (Millipore 0.45 μm) and injected into a 1050 HPLC chromatograph (Agilent Technologies, Inc., Palo Alto, CA, USA) with an Agilent Zorbax SB-C8 4.6 × 250 mm–5μm column maintained at 30 °C. A buffer solution of 50 mM acetic acid/acetate (pH 4) was used as the mobile phase. The flow rate was 0.5 mL min^{-1} and detection was at 260 nm. Quantification was carried out using AA standards solutions. Analyses were carried out in triplicate and the results were expressed as mg of vitamin C kg^{-1} fw.

2.3. Total Antioxidant Activity

Total antioxidant activity (TAA) was estimated in triplicate, according to the method established by Cano et al. [26] with some modifications. Extractions were carried out using 1 g of tomato homogenate diluted in 50 mM Na phosphate buffer (pH 7.5). Then, 20 μL of diluted homogenate was placed in a spectrometric cuvette and 1 mL of the radical cation ABTS (2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) diammonium salt (Sigma-Aldrich, Madrid, Spain) was added. The reaction was monitored in a UV-2401 PC Shimadzu spectrophotometer (Shimadzu Scientific Instruments, Inc., Columbia, MD, USA) at 730 nm, and the decrease in absorbance was determined after 20 min. The results were expressed as mg of Trolox 100 g^{-1} fw.

2.4. Sensory Evaluation

The sensory panel comprised eight trained judges from our institution, all of whom were regular consumers of fresh tomatoes. Each panelist was asked to rate the following sensory attributes: color, sourness, sweetness, juiciness, and consistency. The evaluation was carried out with samples in the *light-red* stage. Firstly, tomatoes were cut into slices of approximately 1 cm thickness and labeled with a random number. The sensory panel evaluated the intensity of the attributes on a 10-point scale, where 0 represented "no intensity" and 10 represented "strong intensity". No information about tomato varieties was provided to the panelists.

2.5. Statistical Analysis

The results were analyzed using SPSS 21.0 statistical software (SPSS Inc, Chicago, IL, USA) by one-way analysis of variance (ANOVA) by ripening stage and variety, and when differences were detected, mean values were compared with Tukey's test ($p < 0.05$). Correlations were performed using Pearson's correlation coefficient (r, $p < 0.01$) to identify significant interactions among studied variables.

3. Results and Discussion

3.1. Total Soluble Solids, Titratable Acidity and pH

The total soluble solid content, pH and tritatable acidity results are presented in Table 2, and acceptability and flavor indexes in Figure 2. TSS content increased with ripening for all varieties, showing the highest values at the last stage (*red*), except in T5, which tended to decrease with maturity. At *turning* and *light-red*, T2 had the highest TSS values, whereas in the *red* stage 'Baghera' showed the highest value together with T2, although the latter was without significant differences with T1 and T4 (Table 2). Ruiz et al. [19] also recorded a higher mean value for a commercial variety in the *red* stage. Although pH values showed

differences among varieties, there was a narrow range of variation: T4 had the lowest value at ***turning***, whereas the maximum was recorded for both T2 and T5 in the ***light-red*** stage. T2 and T3 showed a clear decrease in tritatable acidity with ripening, and together with T5, had the lowest TA values in the ***red*** stage.

Table 2. Tomato quality parameters: TSS, pH, tritatable acidity and firmness.

	Ripening Stage	T1	T2	T3	T4	T5	Baghera
TSS (°Brix)	*turning*	4.55 ± 0.10 c	5.10 ± 0.00 d	4.11 ± 0.21 a	4.45 ± 0.05 bc	4.27 ± 0.15 ab	4.67 ± 0.08 c
	light-red	4.08 ± 0.05 a	5.13 ± 0.10 e	4.33 ± 0.14 ab	4.40 ± 0.00 bc	4.63 ± 0.05 cd	4.80 ± 0.27 d
	red	5.06 ± 0.49 bc	5.13 ± 0.15 cd	4.67 ± 0.10 b	4.93 ± 0.12 bc	4.03 ± 0.06 a	5.55 ± 0.10 d
pH	*turning*	4.41 ± 0.02 bc	4.35 ± 0.01 abc	4.29 ± 0.13 ab	4.24 ± 0.05 a	4.46 ± 0.00 c	4.31 ± 0.05 abc
	light-red	4.40 ± 0.05 a	4.52 ± 0.10 b	4.40 ± 0.02 a	4.32 ± 0.01 a	4.52 ± 0.03 b	4.35 ± 0.03 a
	red	4.38 ± 0.13 a	4.50 ± 0.01 b	4.51 ± 0.02 b	4.33 ± 0.03 a	4.35 ± 0.01 a	4.35 ± 0.01 a
TA (g citric acid 100 g^{-1})	*turning*	0.30 ± 0.01 ab	0.34 ± 0.01 ab	0.37 ± 0.07 b	0.37 ± 0.03 b	0.26 ± 0.01 a	0.34 ± 0.01 b
	light-red	0.32 ± 0.04 b	0.26 ± 0.01 a	0.31 ± 0.01 b	0.34 ± 0.02 b	0.31 ± 0.03 b	0.35 ± 0.02 b
	red	0.33 ± 0.05 bc	0.28 ± 0.01 ab	0.26 ± 0.02 a	0.35 ± 0.02 c	0.29 ± 0.00 ab	0.36 ± 0.02 c
Firmness (force, N)	*turning*	7.54 ± 1.28 b	11.98 ± 1.30 d	6.22 ± 1.06 ab	9.55 ± 1.69 c	5.66 ± 1.38 a	11.32 ± 1.12 d
	light-red	6.70 ± 0.93 bc	6.53 ± 1.53 bc	4.55 ± 0.77 a	6.33 ± 0.91 bc	5.50 ± 1.27 ab	6.79 ± 1.88 c
	red	4.15 ± 1.11 b	5.79 ± 1.79 c	2.75 ± 0.49 a	2.62 ± 0.83 a	3.43 ± 0.84 ab	2.91 ± 1.18 a

Data are expressed as mean values ± standard deviation. In a given row, for a ripening stage, values followed by different letters are significantly different (Tukey's test, $p < 0.05$).
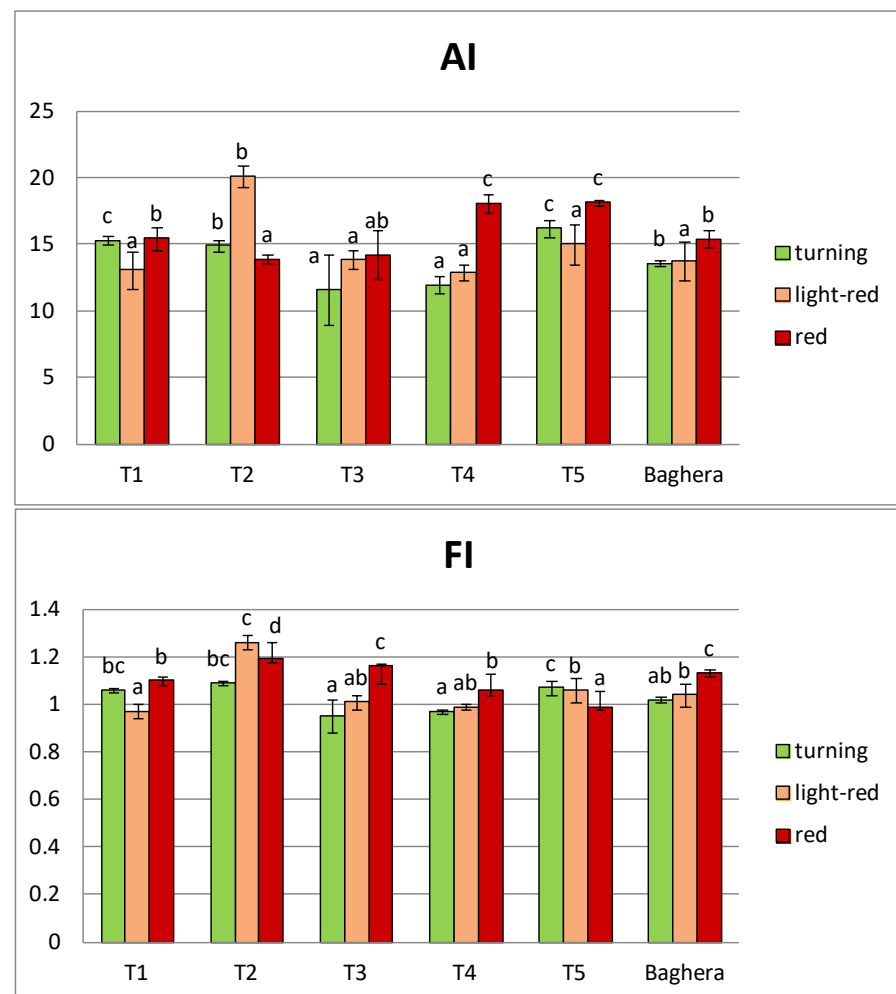
Figure 2. Tomato Aceptability (**AI**) and Flavor (**FI**) Indexes. For each ripening stage, different letters represent significant differences according to Tukey's test ($p < 0.05$). Mean values and standard deviation.

In most varieties, the Acceptability and Flavor Indexes were higher in the *red* stage. T5 and T1 had the highest values of the Acceptability Index at *turning*, and T2 at *light-red*. The latter also had the highest Flavor Index at all ripening stages (Figure 2). For all varieties and ripening stages, Flavor Index values were higher than 0.85, which was described by Hernández et al. [24] as the minimum required value for an acceptable flavor in tomato.

3.1.1. Firmness

It is known that firmness is a tomato quality parameter closely associated with ripening stage [27]. It can be seen in Table 2 and Figure 3 that the firmness of each tomato variety was strongly affected by the ripening stage, and force (N) and slope (Nmm^{-1}) values exhibited a clear decrease as ripening progressed. Therefore, firmness is a useful criterion for assessing the ripening stage of tomato fruits. Although tomatoes harvested in the red stage could be considered the best-tasting tomatoes, these fruits are more fragile and can become easily damaged; thus it is better to harvest them at an earlier stage in order to extend their shelf-life and prevent damage from occurring during handling.
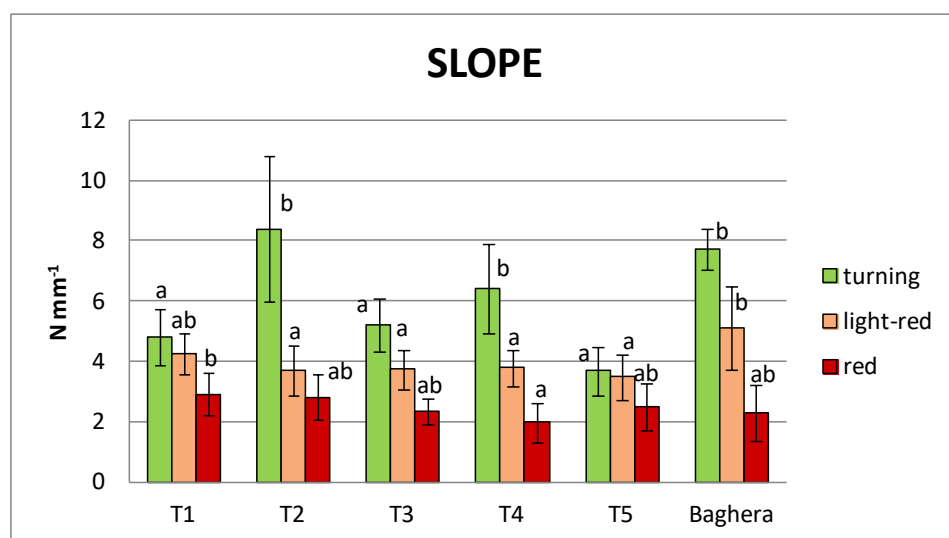
Figure 3. Tomato firmness. For each ripening stage, different letters represent significant differences according to Tukey's test ($p < 0.05$). Mean values and standard deviation.

Differences in maximum force (N) and slope (Nmm^{-1}) were observed among the tomato varieties studied (Table 2, Figure 3). T2 and 'Baghera' recorded the highest firmness values at *turning*. In the *red* stage, all the traditional tomato varieties had similar or higher firmness values than the commercial hybrid 'Baghera'.

3.1.2. Color

Most of the external color parameters decreased with ripening except a* and a*/b*, which increased (Table 3 and Figure 4). The decrease of L* with ripening reflected the darkening of the fruits with carotenoid synthesis, the degradation of chlorophylls and, consequently, the disappearance of greenness [28,29]. As in other studies [13,28], a* values increased from *turning* to *red* as a consequence of lycopene synthesis. C* is not a good indicator of tomato ripening because it is essentially an expression of the saturation of a single color, and as a result, different colors may have the same chroma values [13], as was the case for T4 and 'Baghera'.

Among the studied varieties, there were differences in mean values for all color parameters. At *turning*, T2 revealed the lowest significant values for a*, C* and a*/b* ratio, and the highest significant values for L* and H*. The a ∗ value was slightly negative (−2.87), corresponding to an under-ripe stage and associated with a major accumulation of chlorophylls. In contrast, at *light-red,* T2 showed the lowest values for L*, b*, C*, and H*,

and the highest values for a* and a*/b* ratio. Finally at *red*, T2 presented the significantly highest value of a*/b* (1.74), indicating a more intense red color (Figure 4).

Table 3. Tomato external color parameters.

	Ripening Stage	T1	T2	T3	T4	T5	Baghera
L*	*turning*	49.09 ± 4.30 a	59.89 ± 1.96 c	53.02 ± 3.42 ab	56.34 ± 1.85 bc	52.36 ± 6.02 ab	56.21 ± 4.91 bc
	light-red	48.03 ± 3.42 b	43.30 ± 2.98 a	45.33 ± 4.16 ab	45.70 ± 4.96 ab	46.46 ± 6.41 ab	47.10 ± 2.10 ab
	red	39.73 ± 2.52 b	36.86 ± 1.63 a	36.52 ± 2.94 a	38.12 ± 2.49 ab	36.73 ± 1.79 a	38.25 ± 1.23 ab
a*	*turning*	11.86 ± 4.60 c	−2.87 ± 4.69 a	7.52 ± 2.79 b	7.01 ± 5.14 b	4.13 ± 3.21 b	4.51 ± 1.69 b
	light-red	18.12 ± 4.18 a	22.35 ± 3.08 b	17.54 ± 3.41 a	18.34 ± 4.06 a	19.02 ± 5.55 ab	17.94 ± 3.82 a
	red	27.51 ± 2.33 b	24.21 ± 2.13 a	28.18 ± 1.96 b	24.74 ± 2.95 a	24.59 ± 2.87 a	29.87 ± 2.80 b
b*	*turning*	34.62 ± 4.99 cd	22.97 ± 5.69 a	26.91 ± 5.65 ab	30.77 ± 5.83 bc	43.76 ± 7.61 e	38.95 ± 9.98 de
	light-red	38.07 ± 5.38 d	17.34 ± 1.95 a	31.66 ± 3.38 bc	27.92 ± 4.55 b	35.84 ± 10.88 cd	34.69 ± 2.71 cd
	red	27.33 ± 3.15 cd	13.97 ± 1.36 a	26.26 ± 3.83 bc	25.52 ± 4.42 bc	23.49 ± 2.01 b	29.51 ± 2.65 d
C*	*turning*	36.95 ± 4.14 cd	23.62 ± 5.53 a	28.10 ± 5.47 ab	31.99 ± 5.58 bc	44.08 ± 7.43 e	39.28 ± 9.80 de
	light-red	42.49 ± 4.10 d	28.44 ± 2.11 a	36.31 ± 3.78 bc	33.66 ± 4.36 b	41.32 ± 9.15 d	39.26 ± 2.01 cd
	red	38.84 ± 3.28 c	27.97 ± 2.30 a	38.59 ± 3.57 cd	35.62 ± 4.74 bc	34.05 ± 3.05 b	42.01 ± 3.64 d

Data are expressed as mean values ± standard deviation. In a given row, for a ripening stage, values followed by different letters are significantly different (Tukey's test, *p* < 0.05).
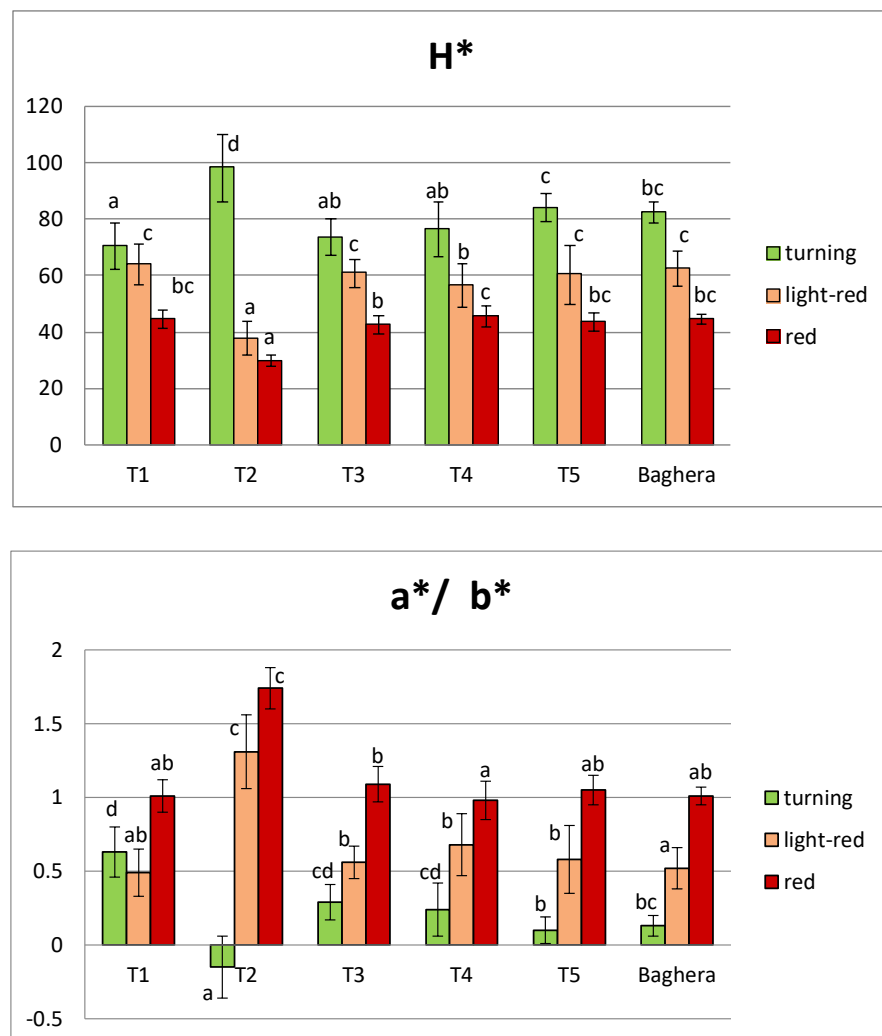
Figure 4. Tomato **Hue angle** and **a*/b*** ratio. For each ripening stage, different letters represent significant differences according to Tukey's test (*p* < 0.05). Mean values and standard deviation.

The ratio a*/b* and H* are often used as indicators of tomato color changes [13,30]. For all varieties, the a*/b* ratio and H* values showed differences among the three ripening stages. There was a progressive decrease in H*, whereas a*/b* ratio increased, as observed in other studies [28,29].

3.1.3. Carotenoids

For lycopene and β-carotene content, differences were found among the studied varieties (Figure 5). Lycopene ranged from 6.57 mg kg^{-1} fw for T2 (*turning*) to 132.64 mg kg^{-1} fw for T4 (*red*). The highest significant lycopene content at *turning* and *light-red* was found for T5, whereas T4 was the variety with the highest concentration at *red*. All the traditional varieties showed higher lycopene content than the commercial hybrid 'Baghera' in the two last stages, although other authors found no differences between commercial and traditional varieties in the red stage [14]. Our tomato varieties showed higher carotenoid content than those reported by Pinela et al. [31] in local farmers' varieties from Portugal. Lycopene content varied significantly among tomato varieties [32] and can be also affected by environmental factors and agricultural techniques [11,33]. Roselló et al. [34] reported values from 2.72 to 73.77 mg kg^{-1} fw for five traditional varieties. In organic production, the average lycopene content has been reported at 56 mg kg^{-1} fw for 13 commercial varieties harvested at the fully ripe stage [30], and Murariu et al. [33] found that the lycopene content of red tomatoes ranged from 9.53 to 3.60 mg 100 g^{-1} fw depending on the genotype and the production system. The values obtained in this work were considerably higher than those reported by these authors, mainly in the *red* stage.

Lycopene content is an internal quality attribute associated with the color and ripening process of tomatoes [28,35–37]. In the studied samples, the lycopene content increased with ripening, on average more than four-fold from the *turning* to *red* stages, reaching the maximum concentration in the *red* stage in all varieties (Figure 5). Lycopene showed a strong Pearson's correlations with different color and firmness parameters. There were positive correlations with a* (0.832) and a*/b* ratio (0.772), and negative with L* (−0.799), H* (−0.801), force (−0.775) and slope (−0.811).

Although lycopene is the most abundant carotenoid in red-ripe tomatoes, β-carotene content was also evaluated. This carotenoid is important because of its pro-vitamin A activity, and it accumulates during tomato fruit ripening [38]. For the studied samples, β-carotene content varied from 5.66 to 16.75 mg kg^{-1} fw. T5 showed the highest content in all stages, but no significant differences were found with T1 at *turning*. Roselló et al. [34] reported β-carotene values from 1.18 to 8.76 mg kg^{-1} fw for five traditional varieties, and Pinela et al. [31] values from 0.30 to 0.51 mg 100 g^{-1} for Portuguese local varieties. The highest concentrations of β-carotene were found in all varieties at *light-red*, except for T2, which recorded the maximum level in the *red* stage, as Gautier et al. [39] reported for other varieties.

3.1.4. Vitamin C

Vitamin C content ranged between 27.33 for T2 (*turning*) and 267.27 mg kg^{-1} fw for T1 (*red*), with differences depending on variety and ripening stage (Table 4).

Table 4. Vitamin C concentration and total antioxidant activity in tomato.

	Ripening Stage	T1	T2	T3	T4	T5	Baghera
Vitamin C (mg kg^{-1} fw)	*turning*	175.05 ± 1.95 d	27.33 ± 1.25 a	96.17 ± 6.23 b	164.28 ± 6.36 c	176.22 ± 9.22 d	155.77 ± 2.61 c
	light-red	137.18 ± 6.92 a	183.73 ± 5.03 c	159.14 ± 5.66 b	159.12 ± 5.08 b	168.54 ± 2.16 b	187.43 ± 2.35 c
	red	267.27 ± 2.90 f	173.85 ± 2.74 b	132.91 ± 3.48 a	249.36 ± 6.27 e	226.45 ± 3.50 d	186.00 ± 1.47 c
TAA (mg Trolox 100 g^{-1} fw)	*turning*	62.32 ± 0.78 b	28.05 ± 0.51 a	60.01 ± 0.91 b	69.83 ± 2.28 c	64.01 ± 1.56 b	63.59 ± 1.68 b
	light-red	63.75 ± 1.07 a	85.41 ± 1.80 c	63.12 ± 1.93 a	72.01 ± 3.19 b	73.81 ± 5.10 b	62.56 ± 1.70 a
	red	63.12 ± 1.47 ab	68.88 ± 1.29 c	61.37 ± 1.77 ab	69.47 ± 1.15 c	65.24 ± 3.70 bc	58.73 ± 1.80 a

Data are expressed as mean values ± standard deviation. In a given row, for a ripening stage, values followed by different letters are significantly different (Tukey's test, $p < 0.05$).
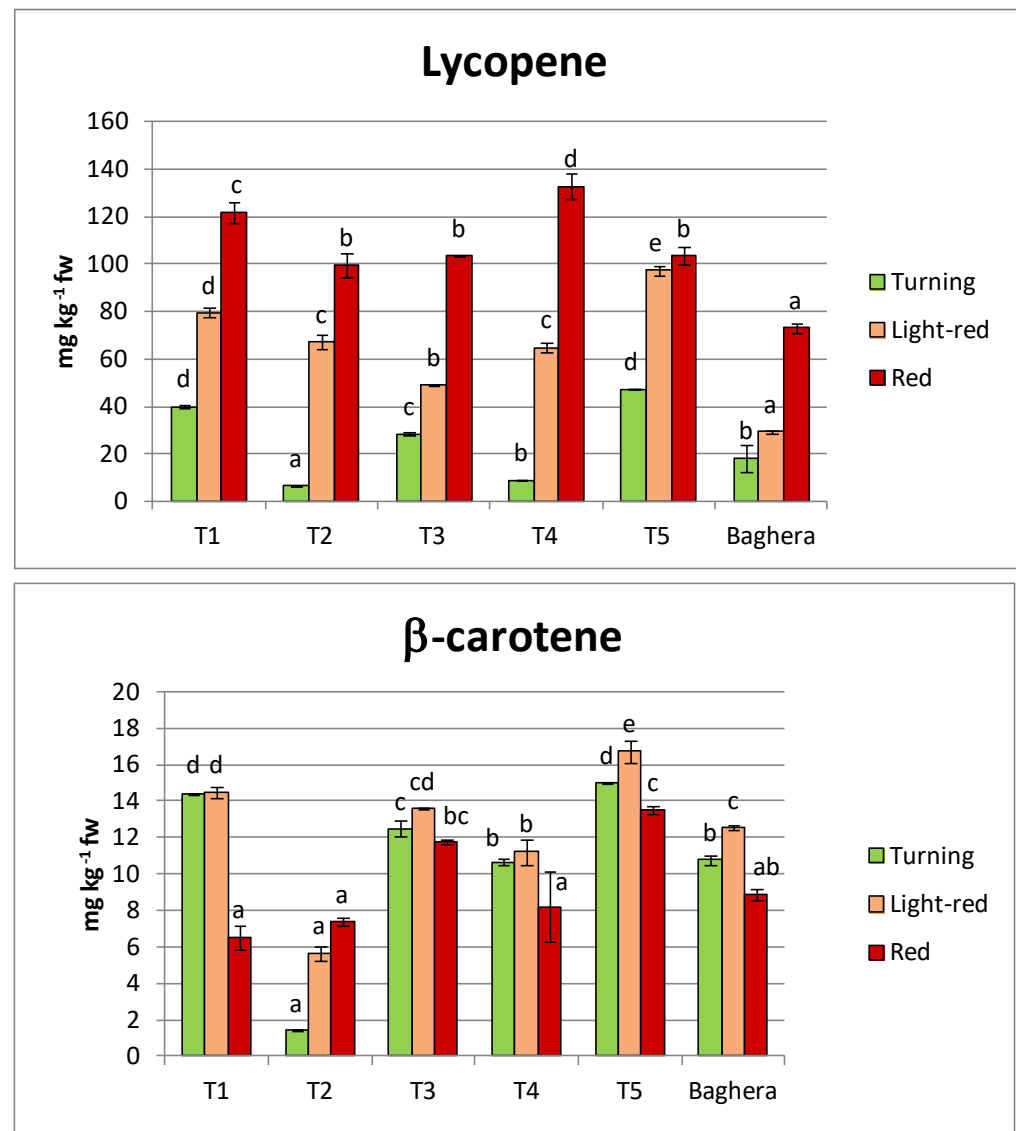
Figure 5. Tomato carotenoids (**lycopene** and **β-carotene**) content. For each ripening stage, different letters represent significant differences according to Tukey's test ($p < 0.05$). Mean values and standard deviation.

At *turning* both T5 and T1 revealed the highest significant concentrations (176.22 and 175.05 mg kg^{-1} fw, respectively), at *light-red* 'Baghera' and T2 (187.43 and 183.73 mg kg^{-1} fw, respectively), and at *red* T1 (267.27 mg kg^{-1} fw). These values were higher than those found by Adalid et al. [2], who reported concentrations of between 51 and 183 mg kg^{-1} for 15 traditional varieties, mainly at a pink stage. For organic tomatoes grown in open air, the vitamin C content observed by Murariu et al. [33] ranged from 11.61 to 29.21 mg 100 g^{-1} fw in the red stage.

As ripening progressed, changes in vitamin C content were observed in the studied varieties (Table 4), in contrast to the results of Raffo et al. [40], who indicated some ascorbic acid variation for cherry tomatoes during ripening. In T1, T4 and T5, vitamin C content decreased slightly from *turning* to *light-red* stage and then increased at *red*. On the other hand, in T2, T3 and 'Baghera' vitamin C accumulated during the first stages and then decreased at *red*, according to other authors [41]. A positive Pearson's correlation between vitamin C and lycopene (0.642) and a negative with H* (−0.608) were found in the studied tomato samples.

3.2. Total Antioxidant Activity (TAA)

TAA values showed differences depending on variety and ripening stage (Table 4), ranging from 28.05 to 85.41 mg Trolox 100 g^{-1} fw, corresponding to T2 at *turning* and *light-red*, respectively. The highest TAA values were found in T4 at *turning* (69.83 mg Trolox 100 g^{-1} fw), in T2 at *light-red* (85.41 mg Trolox 100 g^{-1} fw) and in both T4 and T2 at *red*. On the other hand, the commercial hybrid 'Baghera' showed the lowest values in the *light-red* and *red* stages, although without significant differences with T1 and T3.

Ascorbic acid, together with phenolic compounds, represents the main water-soluble antioxidants in tomato [40], but it must be taken into account that the antioxidant properties of tomatoes largely depend on their lycopene content [37]. Significant correlations between lycopene content and antioxidant activity have been previously reported [38,42]. However, in our study, no such significant correlation was observed.

Most of the tomato varieties did not show differences in TAA values as ripening advanced, as reported by Cano et al. [42]. T2 and T5 exhibited an increase from the *turning* to the *red* stage, with the highest value at *light-red*. In general, higher TAA levels were observed in tomatoes harvested at *light-red*, as found by Raffo et al. [40].

There was also a negative Pearson's correlation (−0.617) between H* and TAA, as previously described for lycopen and vitamin C, so H* could be used as a good indicator of functional quality in tomato.

3.3. Sensory Evaluation

As far as we know, very few sensory analyses of traditional tomato varieties have been carried out. The results of the sensory evaluations carried out with the tomato varieties in the *light-red* stage are depicted in Figure 6. There were significant differences for color, sweetness and juiciness. However, no significant differences were found for sourness and consistency. T4 showed the best value for sourness (7.22) and T2 for consistency (8.16). With respect to color, T3 was the best considered variety (8.16), while no significant differences were found with T1, T2 and 'Baghera'. The highest average score in juiciness corresponded to T2 (8.12), without significant differences with T1, T3 and T4.
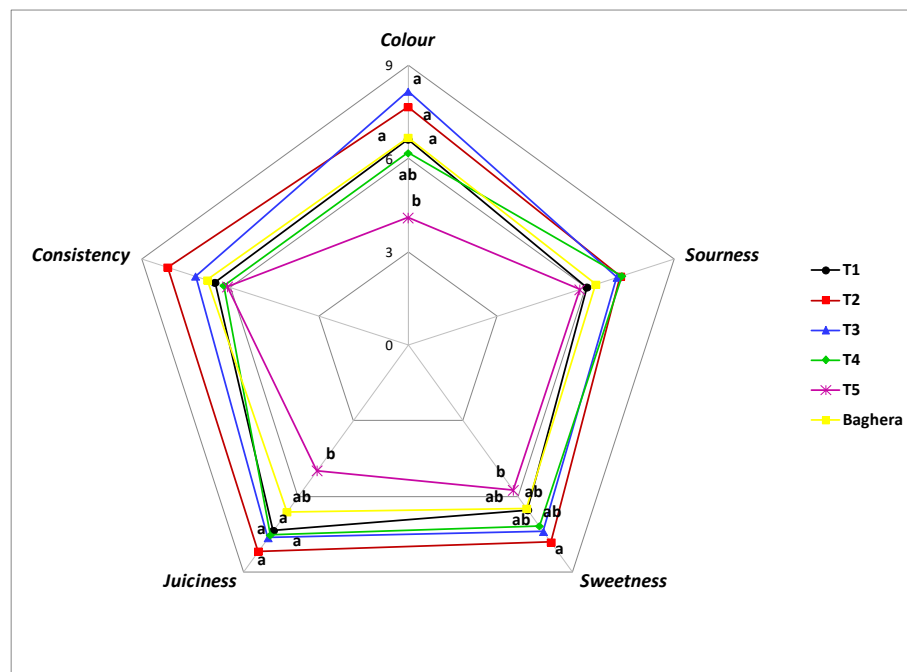
Figure 6. Sensory evaluation results of tomato in the *light-red* stage. For each quality parameter, samples with different letters differed at a significance level of 0.05 according to the Tukey's test (*n* = 8).

T5 was the variety that was least appreciated by panelists. In contrast, T2 achieved the highest scores for sourness and sweetness, which is in accordance with its high values of AI and FI, since these indexes are related to sweetness, sourness and flavor perception.

4. Conclusions

Variety and ripening stage have a strong influence on the physicochemical variables and bioactive compound contents of tomatoes. In general, the traditional varieties showed similar physicochemical characteristics and Acceptability and Flavor Indices to those of 'Baghera', although in the *red* stage, they presented concentrations of lycopen, vitamin C and TAA higher than those 'Baghera'. As expected, the firmness of all the varieties declined and the color parameters L* and H* decreased with ripening, whereas a* and a*/b* increased progressively.

In the *turning* stage, T2 together with 'Baghera' showed the highest values of TSS and firmness, while T1 and T5 stood out in terms of their lycopene and vitamin C contents. In the *light-red* stage, T2 was notable for its highest TSS and vitamin C content, as well as TAA, whereas T5 presented the greatest carotenoid content. In the *red* stage, T4 exhibited remarkable levels of lycopene, vitamin C and TAA. The traditional tomato T2 (at *light-red*) was the variety that was most appreciated by panelists for sweetness and sourness, two major descriptors related to the final taste of tomatoes.

In summary, most of the traditional studied varieties had good quality characteristics and could meet the increasing consumer demand for tasty and healthy food, since they also presented higher concentrations of bioactive compounds at full ripeness.

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