Environmentally Friendly and Safe Technologies for Quality of Fruits and Vegetables

UNIVERSIDADE DO ALGARVE | 2010

The papers contained in this book report some of the peer reviewed Proceedings of the International Conference "Environmentally friendly and safe technologies for quality of fruit and vegetables", but also other papers related with the subject were included. The manuscripts were reviewed by the Editor and Editorial Board, and only those papers judged suitable for publication were accepted. The Editor wish to thank to all the reviewers and authors for their contribution.

Authors are responsible for content and accuracy of their papers.

Proceedings of the International Conference "Environmentally friendly and safe technologies for quality of fruit and vegetables", held in Universidade do Algarve, Faro, Portugal, on January 14-16, 2009. This Conference was a join activity with COST Action 924.

Convener

Carla Nunes, *Universidade do Algarve, Portugal*

Scientific Committee

Carla Nunes, *Universidade do Algarve, Portugal*
Amílcar Duarte, *Universidade do Algarve, Portugal*
Angelos Kanellis, *Aristotle University of Thessaloniki, Greece*
Bart Nicolaï, *Katholieke Universiteit Leuven, Belgium*
Brion Duffy, *Agroscope FAW Wadenswil Bacteriology, Switzerland*
Christian Larrigaudiere, *IRTA-Institut de Recerca i Tecnologia Agroalimentàries, Spain*
Domingos de Almeida, *Universidade do Porto, Portugal*
Josef Streif, *Inst. Sonderkulturen & Produktsphysiologie Hohenheim, Germany*
Krzysztof Rutkowski, *Research Inst. of Pomology and Floriculture, Poland*
Maria Dulce Antunes, *Universidade do Algarve, Portugal*
Maria da Graça Barreiro, *Instituto Nacional de Investigações Agrárias, Portugal*
Mustafa Erkan, *Akdeniz University, Turkey*
Paolo Bertolini, *Universita de Bologna, Italy*
Pol Tijskens, *Wageningen University, Netherland*
Shimshon Ben-Yehoshua, *A.R.O. Volcani Centre, Israel*

Organizing Committee

Carla Nunes, *Universidade do Algarve, Portugal*
Amílcar Duarte, *Universidade do Algarve, Portugal*
Bart Nicolaï, *Katholieke Universiteit Leuven, Belgium*
Maria Dulce Antunes, *Universidade do Algarve, Portugal*
Maria Emília Costa, *Universidade do Algarve, Portugal*
Maribela Pestana, *Universidade do Algarve, Portugal*
Miguel Salazar, *Instituto Universitário Dom Afonso III, Portugal*

Sponsors

COST, European Cooperation in the field of Scientific and Technical Research
Fundação para a Ciência e a Tecnologia
International Association of Students in Agriculture and Related Sciences, Faro
Serviço Técnico Pós-colheita do IRTA em Portugal
Algarve.resorts.net
Câmara Municipal de Faro
Câmara Municipal de Albufeira
Câmara Municipal de Aljezur
Câmara Municipal de Lagos
Câmara Municipal de S. Brás de Alportel
Crédito Agrícola, Caixa do Algarve
A Farrobinha
80 g
C.N. Kopke & C^{a}
PrimeDrinks, S.A.
Uniprofrutal
Frutas Mourinho

SECTION 3. QUALITY MANAGEMENT OF FRUIT AND VEGETABLES

18. TOMATO FRUIT QUALITY AS AFFECTED BY RIPENING ON- AND OFF-VINE

A Koukounaras, C Makridou, AS Siomos*
Department of Horticulture, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
*E-mail address: thankou@agro.auth.gr

Abstract
In order to extend postharvest life and marketable period, tomato fruits are mainly harvested at the mature green stage and they ripen off vine. However, most of the consumers are convinced that on vine ripened tomatoes are of superior quality. The objective of this study was to investigate the quality of tomato fruit (cv. 'Belladona') in relation to their ripening on vine and off vine. During the 10 days of ripening period, color parameters (Lightness, Hue angle and Chroma) were recorded daily. At the end of this period firmness, soluble solids content (ºBrix), pH, titratable acidity, dry matter, nitrates, lycopene, total carotenoids, ascorbic acid, total soluble phenols and DPPH radical scavenging activity were determined. Tomatoes ripened off vine had significantly lower L* and Hue values from the 5th day of ripening and thereafter, indicating more red color than tomatoes ripened on vine. However, there were not significant differences in firmness among fruits of both ripening conditions. Also, the results showed that ripening conditions did not affect soluble solids content, pH, dry matter, SSC/acidity ratio, ascorbic acid, total soluble phenols as well as DPPH radical scavenging activity. On the contrary, tomatoes ripened on vine had significantly higher nitrates and titratable acidity and lower lycopene and total carotenoids than tomatoes ripened off vine.
Keywords: antioxidants, maturity, postharvest ripening, tomato

Introduction
Tomato is one of the most popular vegetables worldwide (Frusciante *et al.* 2007), with advantages the high nutritional value and the availability year-around (Wold *et al.* 2004). The beneficial effect of tomato consumption on human health is correlated with the high content of lycopene, ascorbic acid and other phenolic compounds with strong antioxidant activity (Raffo *et al.* 2006).

The appropriate stage for tomato, a climacteric fruit, harvesting varies from mature green to red and it is depending on the market requirements (Wold *et al.* 2004). In the case of market place far away from production area, the harvest at the mature green stage is critical to avoid overipening before purchase by the consumers (Arias *et al.* 2000). However, most of the consumers are convictive that on vine ripened tomatoes are of superior quality than the fruits which were harvested at the mature green stage and ripened off vine during postharvest handling (Arias *et al.* 2000).

The results for the effect of ripening conditions (on or off vine) on quality of tomatoes are reversely. Better quality (flavour, aroma) for tomatoes ripened on vine was observed previously (Kader *et al.* 1977; Arias *et al*. 2000) as well as higher content of ascorbic acid, lycopene and β-carotene (Kader *et al*. 1978; Arias *et al*. 2000). On the contrary, Giovanelli *et al.* (1999) reported significantly higher antioxidant content (lycopene, β-carotene, ascorbic acid and total phenolics) for tomatoes harvested at the mature green stage and full ripened off vine. Moreover, it has been reported that the ripening conditions (on or off vine) of tomatoes did not affect the ascorbic acid content (Arias *et al.* 2000) and the total antioxidant activity (Wold *et al.* 2004).

The objective of this study was to investigate the quality (color, firmness, chemical composition) of tomato (cv. 'Belladona') as affected by ripening on vine and off vine.

Materials & Methods

Tomatoes (*Lycopersicon esculentum* cv. 'Belladona') were grown in a glasshouse in the experimental farm of the Aristotle University of Thessaloniki, Central Macedonia, Greece under usual production practices. On 9th of May green mature fruits were tagged and half of them were harvested and placed into the laboratory to simulate the postharvest handling of fruits, while the other half remained on the vine. Tomatoes on and off vine were allowed to ripen for 10 days, while temperatures (minimum, maximum) in the glasshouse and in the laboratory were recorded. During this period the color of the selected fruits was measured daily with a chromameter (Minolta CR-200, Japan) and color changes were quantified in the L*, a* and b* color space. Hue angle and chroma values were calculated from a* and b* values (McGuire 1992).

When fruit were ripe, their firmness was recorded using a 3 mm probe of a Chatillon penetrometer. Furthermore, fruit of each replication were macerated in a blender for compositional analysis. Dry matter content was determined after drying about 40 g of the blended material in an oven set at 70 °C for 72 h. Soluble solids content (SSC) was measured in the blended material by a digital refractometer Atago PR-1 (Japan). The pH and titratable acidity were determined in a 50-ml filtrate obtained from a blend of 10 g blended material in 100 mL deionised water. The filtrate was titrated to pH 8.2 with 0.01 N NaOH. Ascorbic acid was extracted in 1% oxalic acid and measured by using Reflectoquant ascorbic acid test strips in an RQflex reflectometer (Merck, Germany). Nitrate content was determined colorimetrically, as described by Cataldo *et al.* (1975). Lycopene and total carotenoids were extracted in acetone and the absorbance was measured at 503 and 445 nm, respectively. Total soluble phenol content was determined according to Scalbert *et al.* (1989) with gallic acid used as a standard. DPPH radical scavenging activity was determined using a modified method of Brand-Williams *et al.* (1995) as described by Koukounaras *et al.* (2007). The standard curve was developed with ascorbic acid.

The experimental design was a completely randomized one with three replications, each one consisting of two fruit. Data for color was subjected to analysis of variance and mean separation was conducted by LSD at 0.05 level.

Results & Discussion

Both on- and off-vine tomatoes showed a great alteration in color parameters (a decrease of L* and Hue and an increase of C*) during ripening. However, off vine ripened tomatoes had significantly lower L* and Hue values from the 5th day and thereafter, as well as, significantly higher C* values from the 5th till to the 9th day (Fig 1). These results indicate that tomato fruits ripened off vine had more red color at the end of the 10 days period. The above result is a consequence of the significantly higher (by 73.4%) content of lycopene in off vine ripened tomatoes (Table 1). It is well known that the lycopene biosynthesis is inhibited at high temperatures (>38 °C) (Cheng *et al.* 1988). In the glasshouse the maximum temperature for some days was higher than 38 °C, while in the laboratory the maximum temperature was 22.5 °C (Table 2).

Table 1. Ascorbic acid, lycopene, total carotenoids, total soluble phenols and DPPH radical scavenging activity of tomato fruits as affected by ripening conditions (on- and off-vine).

Ripening conditions	Ascorbic acid (mg 100 g^{-1} f.w.)	Lycopene (μg g^{-1} f.w.)	Carotenoids (μg g^{-1} f.w.)	Phenols (GAE g^{-1} f.w.)	DPPH (AEAC 100 g^{-1} f.w.)
On vine	14.17 a[z]	16.98 b	21.77 b	0.40 a	24.20 a
Off vine	12.38 a	37.73 a	37.73 a	0.45 a	17.47 a

[z] Each value is the mean of the three replications

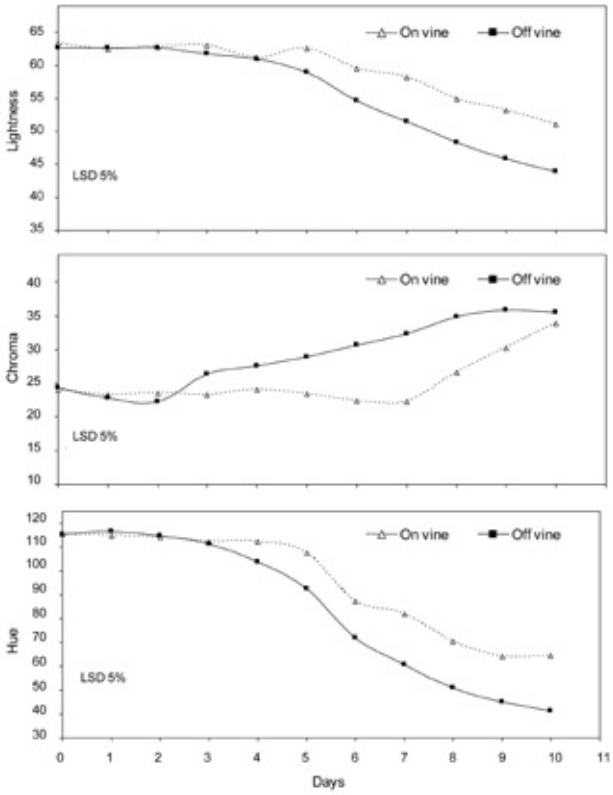

Fig 1. Color parameters (Lightness, Chroma and Hue angle) of tomato fruits as affected by ripening conditions.

Table 2. Minimum, maximum and mean temperature into glasshouse and laboratory during ripening period of tomatoes.

	Glasshouse Temperature (°C)			Laboratory Temperature (°C)		
Day	Minimun	Maximum	Mean	Minimun	Maximum	Mean
1st	15	37	26.5	21	21	21.0
2nd	12	40	26.0	20	21	20.5
3rd	12	37	24.5	21	21	21.0
4th	11	38	24.5	20	21	20.5
5th	15	41	28.0	21	21	21.0
6th	11	38	24.5	20	22	21.0
7th	12	35	23.5	20	22	21.0
8th	16	44	30.0	21	22	21.5
9th	14	43	28.5	21	23	22.0
10th	14	44	29.0	22	23	22.5

Firmness of the fruits ripened on and off the vine were not significantly different (0.99 and 1.09 kg, respectively). On the contrary, significantly higher firmness for on vine tomatoes as compared to off-vine ripening has been reported by Arias *et al.* (2000).

The nitrates and titratable acidity were significantly higher for the fruits ripened on vine (Table 3). On the contrary, no significant effect on acidity for on- and off-vine fruits was observed by Arias *et al.* (2000) and Picha (1986).

Table 3. Dry matter, nitrate, SSC, pH, titratable acidity and SSC/acidity ratio of tomato fruits as affected by ripening conditions (on- and off-vine).

Ripening conditions	Dry matter (%)	Nitrate (mg kg^{-1} f.w.)	SSC (%)	pH	Acidity (% citric)	SSC/Acidity
On vine	6.65 a[z]	114.73 a	5.57 a	3.87 a	0.29 a	19.18 a
Off vine	6.37 a	91.99 b	4.63 a	3.94 a	0.25 b	18.61 a

[z] Each value is the mean of the three replications.

The ripening conditions did not affect soluble solids content, pH, dry matter, SSC/acidity, ascorbic acid, total soluble phenols as well as DPPH radical scavenging activity (Tables 1, 3). Other authors (Arias *et al.* 2000; Wold *et al.* 2004) reported the same results for ascorbic acid and the total antioxidant activity.

Also, we found that the SSC/Acidity ratio was similar for both fruits ripened on- and off-vine (Table 3). It is well known that the sugars/acid ratio is a basic parameter for the quality classification of fresh tomatoes (Kader *et al.* 1977).

From the above results it is evident that the ripening mechanism was not significantly affected by the ripening conditions, although differences in color due to differences in lycopene content were detected, which could be attributed to differences of temperatures between the two ripening conditions.

In conclusion, on-vine ripened tomato fruits had less red color, lower lycopene content and total carotenoids, higher nitrates and acidity than the off-vine ones and similar firmness, dry matter, soluble solids, pH, ascorbic acid, antioxidants and SCC/acidity ratio.

References

Arias R, Lee T-C, Specca D, Janes H. 2000. Quality comparison of hydroponic tomatoes (*Lycopersicon esculentum*) ripened on and off vine. *J Food Sci* 65:545-8

Brand-Williams W, Cuvelier ME, Berset C. 1995. Use of free radical method to evaluate antioxidant activity. *Food Sci Technol* 28:25-30

Cataldo DA, Haroon M, Schrader LE, Youngs VL. 1975. Rapid colorimetric determination of nitrate in plant tissue by nitration of salicylic acid. *Commun Soil Sci Plant Anal* 6:71-80

Cheng TS, Floros JD, Shewfelt RL, Chang CJ. 1988. The effect of high temperature stress on ripening of tomatoes (*Lycopeusicon esculentum*). *J Plant Physiol* 132: 459-64

Frusciante L, Carli P, Ercolano MR, Pernice R, Di Matteo A, Fogliano V, Pellegrini N. 2007. Antioxidant nutritional quality of tomato. *Mol Nutr Food Res* 51:609-17

Giovanelli G, Lavelli V, Peri C, Nobili S. 1999. Variation in antioxidant components of tomato during vine and post-harvest ripening. *J Sci Food Agr* 79:1583-8

Kader AA, Stevens MA, Albright-Holton M, Morris LL, Algazi M. 1977. Effect of fruit ripeness when picked on flavor and composition in fresh market tomatoes. *J Amer Soc Hort Sci* 102:724-31

Kader AA, Morris LL, Stevens MA, Albright-Holton M. 1978. Composition and flavor quality of fresh market tomatoes as influenced by some postharvest handling procedures. *J Amer Soc Hort Sci* 103:6-13

Koukounaras A, Siomos AS, Sfakiotakis E. 2007. Postharvest CO_2 and ethylene production and quality of rocket (*Eruca sativa* Mill.) leaves as affected by leaf age and storage temperature. *Postharvest Biol Technol* 46:167-73

McGuire RG. 1992. Reporting of objective color measurements. *HortScience* 27:1254-5

Picha D. 1986. Effect of harvest maturity on the final fruit composition of cherry and large-fruited tomato cultivars. *J Amer Soc Hort Sci* 111:723-7

Raffo A, La Malfa G, Fogliano V, Maiani G, Quaglia G. 2006. Seasonal variations in antioxidant components of cherry tomatoes (*Lycopersicon esculentum* cv. Naomi F1). *J Food Composit Anal* 19:11-9

Scalbert A, Monties B, Janin G. 1989. Tannins in wood: Comparison of different estimation methods. *J Agr Food Chem* 37:1324-9

Wold AB, Rosenfeld HJ, Holte K, Baugerød H, Blomhoff R, Haffner K. 2004. Colour of post-harvest ripened and vine ripened tomatoes (*Lycopersicon esculentum* Mill.) as related to total antioxidant capacity and chemical composition. *Int J Food Sci Technol* 39:295-302