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Original Article

# Nutrient composition and antioxidant activity of eight tomato (*Lycopersicon esculentum*) varieties

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ABSTRACT

The nutritional composition of eight tomato varieties collected from greenhouses in Almería (Spain) was determined. The analyzed components included moisture, crude protein, available carbohydrates, total lipids, dietary fiber, ash, energy, vitamin C, fatty acids, carotenoid profiles, mineral elements, nitrate and oxalic acid. The output of the analyses showed higher amounts of vitamin C and carotenoid in these tomato varieties than in conventional varieties. All varieties reported in this study showed high amounts of nitrates, ranging between 108 mg in Rambo and Racimo and 470 mg in Cherry (mg/100 g fresh wt). The antioxidative capacity of the tomato extracts, evaluated both with the β-carotene breaching and with the 2,2-diphenyl-1-picrylhydracyl (DPPH$^{\bullet}$) radical scavenging methods, showed that the antioxidant activity of the extracts of some verities was comparable with those of the commercial antioxidants used for similar purposes.



## 1. Introduction

Tomatoes are an integral part of diet worldwide. Many population studies have established a link between dietary intake of tomatoes, a major source of the antioxidant lycopene, and a reduced risk of cancer and cardiovascular diseases (Agarwa and Aai, 2000). The fruits of *Lycopersicum esculentum* owe their intense red color to carotenoid pigments that are synthesized massively during fruit ripening. Carotenoids are responsible for the final red color of the tomato (Zeb and Mehmood, 2004). In addition to lycopene, violaxanthin, neoxanthin, lutein, zeaxanthin, α-cryptoxanthin, β-cryptoxanthin, α-carotene, β-carotene, γ-carotene, ζ-carotene, neurosporene, phytoene, phytofluene, cyclolycopene and β-carotene 5,6-epoxide are other carotenoids commonly cited in tomato and tomato-derived products (Fraser et al., 1994; Khachik et al., 2002; Burns et al., 2003; Paetau et al., 1998). Among these, α-carotene, β-carotene and β-cryptoxanthin have pro-vitamin A activity, since they are converted to retinal by mammals (Burns et al., 2003).

Other valuable nutritional components of tomatoes are several minerals and vitamin C, which were first studied many years ago (Halevy et al., 1957). These nutrients can vary largely depending on growing conditions. In fact, it has been established that tomatoes grown on organic substrates contained significantly more Ca and vitamin C and less Fe than did fruit grown on hydroponic media. Conversely, P and K content did not differ in fruit grown on either organic or hydroponic substrates (Premuzic et al., 1998).

Toxic and antinutritional compounds, such as oxalic acid (Raffo et al., 2002; Thakur et al., 2001) and nitrate (Chapagain et al., 2003; Santamaria, 2006) have also been described in varying quantities in tomatoes.

The antioxidant capacity of several tomato varieties has been also tested. It has been established that the antioxidant activity of tomato extracts varies with the tomato variety and the assay method used. Individual compounds found to be significantly related to antioxidant capacity are lycopene and ferulic and caffeic acids (Martínez-Valverde et al., 2002).

At present, there exist a large number of tomato cultivars with a wide range of morphological and sensorial characteristics which determine their use. In the past 30 years a significant increase in vegetable cultivation has taken place in Almería (Spain), which is due to the generalized use of greenhouses, allowing better control of nutrients available to plants. New tomato varieties are thus being widely cultured, but their nutritional composition has remained unreported until now. The main purpose of this study

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was to describe the nutritional value and the antioxidant activity of eight under-analyzed tomato varieties from Almería (Spain).

## 2. Materials and methods

### 2.1. Samples

Each tomato variety was collected in at least five agricultural cooperative groups from Almería (Spain). All tomatoes were grown in greenhouse conditions. These five agricultural cooperatives constitute major suppliers of tomatoes in this region in Spain. All tomatoes from the same variety can be considered closely similar, and no cultivar consideration might be made for tomatoes having different origin, by considering the following factors:

- All seeds for all tomato varieties are supplied by the same commercial supplier
- Water, soil, fertilizers and other cultivar requirements are the same for each tomato variety, because all agricultural practices are closely standardized by cooperative regulations

Tomatoes were randomly selected at different harvesting periods according to the criteria used by technical personnel for quality control in each of the selected cooperatives. The time that elapsed from sample collection until lab analysis, and the time employed by vegetable carriers to commercially distribute tomatoes from cooperatives, were approximately the same, so the ripening stage at which samples for this study were selected was the same as when the tomatoes are normally consumed. The "pink" and "breaker" ripening stages at which some tomato varieties were collected were consistent with commercial presentations and consumer preferences. After collecting, the fruits were packed in a portable refrigerator until they were transported to the laboratory (2–3 h).

The ripening stage for all samples was selected in good agreement with those at which each variety is usually consumed. The ripening stage for all collected varieties is shown in Table 1. For analyses, only edible parts were used. Samples were collected between September and December 2003. Before performing the analyses, the samples were washed, first with running water and then with distilled water, and residual moisture was evaporated at room temperature. Then, five fruits from each variety from each cooperative were chopped into small slices, coded (fruit number, variety, cooperatives) and lyophilized or analyzed. For analyses, an appropriate number of slices were added to running samples until the analyses were performed. Carotenoids and vitamin C were analyzed immediately, and the remaining samples were dried in a freeze-drying apparatus. The dried samples were packed in new plastic bags and stored in desiccators (silica gel as desiccant) for a maximum of 2–3 days until other analyses were carried out.

For antioxidant activity, the extraction of dried vegetables was accomplished by using methanol, thus ten extracts were obtained. Samples (100 mg) were mixed with 25 mL of the solvent and placed in hermetic glass containers with inert atmosphere of nitrogen. After agitation for 6 h, at room temperature, the solution was filtered under vacuum. The obtained powder was twice extracted, and the extracts from each plant were mixed and lyophilized, and finally stored at −20 °C.

Moisture was determined by drying a representative 2 g sample in an oven with air circulation at 100–105 °C for 40 h (AOAC, 1984).

### 2.2. Proximate composition

Total nitrogen was determined by means of an elemental analyzer (Leco CHNS-932). The carrier gas was He, while oxygen was the burning gas (Rebolloso-Fuentes et al., 2000). Total carbohydrates were determined spectrophotometrically with anthrone (Osborne, 1985). Total lipids were determined as the extract obtained with chloroform:methanol (2:1) (v/v) (Kochert, 1978). Dietary fiber was determined by the neutral detergent fiber method (Goering and Van Soest, 1970; Johnson and Marlett, 1986). Ash was determined according to AOAC procedure (method 7009, 1984) by incineration of a representative 0.5 g sample in an oven at 450 °C for 48 h. Sulphur was determined by means of an elemental analyzer (Leco CHNS-932). The carrier gas was He, while oxygen was the burning gas (Rebolloso-Fuentes et al., 2000). Phosphorus was determined spectrophotometrically by the molybdate–metavanadate method (Guil Guerreroa et al., 1998).

### 2.3. Energy content

The energy content of the biomass was determined by multiplying the values obtained for protein, available carbohydrates and fat by 4.00, 3.75 and 9.00 respectively, and adding up the results (AOAC, 1984).

### 2.4. Vitamin C

Vitamin C was estimated by the 2,4-dinitrophenylhidrazine method in conjunction with spectrophotometric measurement (Osborne, 1985).

### 2.5. Fatty acids

Fatty acid methyl esters (FAME) were prepared directly from freeze-dried fruits (200 mg) by transmethylation of the lipid

**Table 1**
Ripening stage, proximate composition and vitamin C content of eight tomato varieties (on 100 g fresh wt)[*,**].

| Variety[***] | Ripeness color[****] | Moisture (g) | Crude protein (g) | Available carbohydrates (g) | Lipids (g) | Neutral detergent fiber G | Ash (g) | *E* (kcal) | *E* (kJ) | Vitamin C (mg) |
|---|---|---|---|---|---|---|---|---|---|---|
| Cherry (4) | Light Red | $95.2 \pm 1.2^a$ | $0.78 \pm 0.02^a$ | $1.27 \pm 0.5^a$ | $0.49 \pm 0.05^a$ | $1.13 \pm 0.11^a$ | $0.90 \pm 0.10^a$ | $12.3 \pm 01.3^a$ | $51.5 \pm 5.4^a$ | $82 \pm 20^a$ |
| Cherry Pera (3) | Breakers | $92.6 \pm 1.3^a$ | $1.05 \pm 0.06^b$ | $2.18 \pm 0.29^b$ | $0.42 \pm 0.06^a$ | $1.60 \pm 0.11^b$ | $1.41 \pm 0.09^b$ | $16.2 \pm 2.3^a$ | $67.6 \pm 9.1^a$ | $39 \pm 12^b$ |
| Daniela Larga Vida (4) | Pink | $96.0 \pm 1.0^a$ | $0.8 \pm 0.02^a$ | $1.26 \pm 0.32^a$ | $0.28 \pm 0.06^b$ | $0.74 \pm 0.10^c$ | $0.75 \pm 0.14^a$ | $10.4 \pm 1.8^a$ | $43.7 \pm 7.9^a$ | $62 \pm 12^c$ |
| Lido (3) | Pink | $94.7 \pm 0.8^a$ | $0.75 \pm 0.08^a$ | $1.56 \pm 0.23$ | $0.67 \pm 0.04^c$ | $1.10 \pm 0.09^a$ | $1.00 \pm 0.11^a$ | $14.9 \pm 2.0^a$ | $62.3 \pm 8.1^a$ | $130 \pm 25^d$ |
| Pera (4) | Light Red | $96.0 \pm 1.4^a$ | $0.56 \pm 0.03^c$ | $1.16 \pm 0.09^a$ | $0.26 \pm 0.04^b$ | $0.78 \pm 0.15^c$ | $0. 78 \pm 0.13^a$ | $8.9 \pm 1.6^a$ | $37.4 \pm 6.4^a$ | $164 \pm 22^d$ |
| Racimo (4) | Light Red | $93.3 \pm 1.4$ | $0.91 \pm 0.10^b$ | $1.91 \pm 0.44^b$ | $0.20 \pm 0.04^b$ | $1.25 \pm 1.14^a$ | $1.25 \pm 0.16^b$ | $12.6 \pm 1.7^a$ | $52.8 \pm 7.0^a$ | $174 \pm 21^d$ |
| Raf (3) | Pink | $93.9 \pm 1.5^a$ | $0.96 \pm 0.07^b$ | $2.04 \pm 0.68^b$ | $0.47 \pm 0.06^a$ | $1.27 \pm 0.11^a$ | $1.14 \pm 0.14^b$ | $15.7 \pm 1.9^a$ | $65.8 \pm 4.9^a$ | $155 \pm 0.10^d$ |
| Rambo (3) | Breakers | $95.8 \pm 0.8^a$ | $0.55 \pm 0.08^c$ | $1.01 \pm 0.61^a$ | $0.44 \pm 0.03^a$ | $0.99 \pm 0.12$ | $0.82 \pm 0.18$ | $9.9 \pm 1.0^a$ | $41.6 \pm 4.2^a$ | $263 \pm 22^e$ |

[*] Each result is expressed as the average ± S.D. of the analysis of five different tomatoes of each variety, for a range of three to four suppliers by variety.
[**] Values within a row followed by the same superscript letter were not significantly different ($p \le 0.05$) by the Duncan's Multiple Range Test.
[***] The number of suppliers by variety is indicated in brackets.
[****] USDA Tomato Ripeness Color Chart.