Since 2000, the high significance of strawberry (Fragaria ×ananassa Duch.) production in Huelva, located on the southwest coast of Spain, has led public and private institutions to increase the releasing of new cultivars that are well adapted to the climate characteristics and growing conditions in Huelva and other mild areas. The Spanish public breeding program has contributed to this effort with cultivars such as 'Andana', 'Carisma', 'Marina', 'Medina', 'Aguedilla', and 'Fuentepeina' (Bartual et al., 1997, 2002; López-Aranda et al., 2004, 2005a, 2005b; Soria et al., 2010).

'Santaclara' is a new short-day cultivar recently released by the Spanish public breeding program, participating in the Spanish National Agricultural Research Institute (INIA), the Andalusian Institute of Agriculture and Fishery Research and Training (IFAPA) as well as the private partners Fresas Nuevos Materiales S.A. (FNM), Freshuelva Viveristas (FV), and Nuevas Técnicas de Fresa S.L. (NTF). The main purpose of this program is to breed cultivars for high yield, large fruit size for the fresh market, and high fruit quality and which outperform currently grown short-day cultivars in mild climate areas (e.g., 'Camarosa').

'Santaclara' is noted for its medium- to high-balanced agronomic, postharvest, and fruit quality traits (including nutraceutical values). 'Santaclara' also shows excellent comparative values for the fresh market and adapts well to mild agroenvironments.

This new cultivar was named after an old monastery founded in 1337 and located at Moguer (Huelva), place of birth of the 1965 Nobel prize awarded poet Juan Ramón Jiménez, who spent his youth in the strawberry production area around this nice village.

**Description**

'Santaclara' is described subsequently following the International Union for the Protection of New Varieties of Plants (UPOV) guidelines (UPOV, 1995), and differences with 'Camarosa', when exist, are shown.

'Santaclara' is a short-day strawberry cultivar. Plant vigor is medium with a globose growth habit. When planted in high-elevation nurseries in mid-April, plants tend to produce many runners with very low anthocyanin coloration and medium pubescence. Leaves are strongly to slightly concave and medium blistering with three dark green medium-glossy leaflets.; in contrast to the weak blistering, medium green leaflets of 'Camarosa'. The terminal leaflet is longer than wide with an obtuse base and crenate margins, whereas the terminal leaflet of 'Camarosa' is as long as wide.

Inflorescences are located at the end of long peduncles and flowers open at the level of the canopy. Flower size is medium and the calyx diameter is higher than the corolla. The corolla has five overlapping white petals that are broader than longer in contrast to ‘Camarosa’ that shows as long as broad touching petals. The conical berries are large, much longer than broader (Fig. 2), with medium red flesh and external color. The internal cavity is either small or medium expressed. The fruit surface is even, achenes are inserted leveled with the surface, and the band without achenes is absent or very narrow; 'Camarosa' fruit surface is darker and slightly uneven with achenes inserted below the surface. The calyx of 'Santaclara' is firmly attached to the fruit with a slightly larger diameter. The fruit flesh is very firm, pleasantly aromatic, and tasty.

Early and total yields for 'Santaclara' are similar to those of standard cultivars grown in southwestern Spain such as 'Camarosa' and 'Sabrosa' (Table 1). Post-harvest tests showed that 'Santaclara' has a good shelf life, similar to that of 'Camarosa' and 'Sabrosa' and longer than that of 'Aguedilla' and 'Ventana' (Table 3). The best attributes of 'Santaclara'
are its remarkably high fruit firmness and a very high ascorbic acid content (vitamin C) (Table 4).

Genetic characterization of ‘Santaclara’ (Gil-Ariza et al., 2006) using three microsatellites yielded the following patterns: ChFaM001: 244, 231, 212; ChFaM002: 174, 164; and ChFaM004: 187, 173, 147, 145, 137.

Table 1. Fruit yield of ‘Santaclara’ versus standard strawberry cultivars grown at Huelva (Spain) during 2008, 2009, and 2010 seasons.

| Cultivar | Marketable (g/plant) | Second quality (%) | Marketable (g/plant) | Second quality (%) | Fruit wt (g/fruit) |
|----------|----------------------|--------------------|----------------------|--------------------|-------------------|
| 2008     |                      |                    |                      |                    |                   |
| Santaclara | 585 ab | 9.5 b | 1007 b | 11.6 b | 26.0 bc |
| Camarosa | 528 bc | 15.4 a | 996 b | 17.1 a | 25.1 c |
| Ventana | 632 a | 6.3 c | 1079 ab | 11.3 b | 25.4 bc |
| Aguedilla | 624 a | 4.3 d | 1163 a | 9.1 bc | 31.7 a |
| Amiga | 446 cd | 1.9 e | 1072 ab | 8.1 c | 27.7 b |
| Fuentequina | 427 d | 6.7 c | 728 c | 7.6 c | 25.5 bc |
| 2009     |                      |                    |                      |                    |                   |
| Santaclara | 340 ab | 10.4 ab | 781 a | 11.7 b | 25.8 a |
| Camarosa | 387 a | 12.8 a | 832 a | 17.1 a | 26.7 c |
| Sabrosa | 239 c | 5.9 bc | 717 ab | 12.2 b | 25.0 c |
| Aguedilla | 384 a | 6.4 bc | 882 a | 11.6 b | 32.1 a |
| Fuentequina | 266 bc | 3.4 c | 563 b | 6.2 c | 29.1 b |
| 2010     |                      |                    |                      |                    |                   |
| Santaclara | 289 bc | 9.8 abc | 831 b | 10.6 b | 24.4 c |
| Camarosa | 269 c | 11.0 a | 807 b | 14.2 a | 25.7 bc |
| Sabrosa | 288 bc | 6.1 de | 803 bc | 11.6 b | 25.0 bc |
| Splendor | 341 a | 8.3 bc | 912 a | 11.5 b | 26.7 ab |
| F. Fortuna | 287 bc | 8.1 cd | 689 d | 9.6 b | 25.3 bc |
| Primoris | 310 ab | 10.0 ab | 866 ab | 14.4 a | 24.2 c |
| Antilla | 261 c | 3.5 f | 708 d | 7.1 c | 28.4 a |
| Fuentequina | 314 ab | 4.2 ef | 735 ed | 5.6 c | 25.7 bc |

1 Early yield: up to the end of March.
2 Mean values in each column followed by different letters are significantly different at \( P \leq 0.05 \) as determined by Fisher’s least significant difference test.

Table 3. Shelf life parameters of ‘Santaclara’ and other strawberry cultivars grown in Huelva, Spain, during the 2008, 2009, and 2010 crop seasons.

| Cultivar | Calyx freshness (%) | Bruising (%) |
|----------|---------------------|--------------|
| 2008     |                     |              |
| Santaclara | 5.2 ab | 6.2 a |
| Camarosa | 5.2 ab | 5.8 ab |
| Ventana | 4.0 b | 4.7 bc |
| Aguedilla | 4.7 ab | 4.3 c |
| Amiga | 4.5 b | 7.0 a |
| Fuentequina | 6.2 a | 6.7 a |
| 2009     |                     |              |
| Santaclara | 6.0 a | 5.0 ab |
| Camarosa | 6.7 a | 5.3 ab |
| Sabrosa | 6.7 a | 6.3 a |
| Aguedilla | 5.2 a | 3.7 b |
| Fuentequina | 6.3 a | 5.5 a |
| 2010     |                     |              |
| Santaclara | 4.8 abc | 6.0 a |
| Camarosa | 4.4 bc | 6.0 a |
| Sabrosa | 5.1 bc | 6.3 a |
| Splendor | 5.5 ab | 5.8 a |
| F. Fortuna | 3.8 c | 6.1 a |
| Primoris | 5.8 a | 6.8 a |
| Antilla | 5.7 ab | 6.7 a |
| Fuentequina | 5.3 ab | 5.9 a |

1 Rated on a scale from 3 to 7, where 3 = light red and 7 = deep red.
2 Rated on a scale from 3 to 7, where 3 = absent and 7 = large internal cavity along the fruit.
3 Within columns, mean values followed by different letters are significantly different at \( P \leq 0.05 \) as determined by the Kruskal-Wallis comparison test.
4 Within columns, mean values followed by different letters are significantly different at \( P \leq 0.05 \) as determined by Fisher’s least significant difference test.

Cultivar and Germplasm Releases

During the 2008, 2009, and 2010 seasons, ‘Santaclara’ fruit yield (Table 1), fruit quality (Table 2), and shelf life traits (Table 3) were assessed and compared with several well-adapted short-day cultivars: ‘Camarosa’, ‘Ventana’, ‘Aguedilla’, ‘Amiga’, ‘Fuentequina’, ‘Sabrosa’, ‘Splendor’, ‘Florida Fortuna’ (named ‘Florida Radiance’ in USA), ‘Primoris’, and ‘Antilla’. Throughout those 3 years, cultivar performance was evaluated in experimental fields in the strawberry production area of Moguer (Huelva).

To reduce the presence of soilborne pathogens, an experimental plot soil was solarized and biofumigated each year (Medina et al., 2009) before planting.

During the third week of October of each year (2008, 2009, and 2010), plants were planted in three completely randomized plots of 50 plants each on two-row raised beds covered with black plastic and drip irrigation pipes under the plastic. Plants were spaced 0.25 × 0.25 m apart. In mid-November plants were covered with large plastic (150 μm) tunnels (6.6 m wide × 3.5 m high × 70 m long). Between mid-November and mid-May, the fertilizer rate was: 175 kg N/ha, 77 kg P2O5/ha, 185 kg K2O/ha, 85 kg CaO/ha, and 14 kg MgO/ha. Marketable fruits (first-plus second-quality fruits; no misshapen fruits of 17 g or greater and between 10 and 17 g, respectively) were harvested and weighed once or twice a week from early January to late May.

Fruit weight was calculated by weighing 20 first-quality fruits eight times throughout the season and dividing total weight by the number of harvested fruits (160). Three times per season (mid-February, mid-March, and mid-May), six randomly chosen fruits per plot were evaluated for quality traits such as external and internal color, internal cavity size, firmness, and soluble solid content and ‘Sabrosa’, ‘Splendor’, ‘Florida Fortuna’ (named ‘Florida Radiance’ in USA), ‘Primoris’, and ‘Antilla’. Throughout those 3 years, cultivar performance was evaluated in experimental fields in the strawberry production area of Moguer (Huelva).
only twice (mid-February and mid-May) for acidity. Color and cavity size were subjectively rated on a visual scale (Table 2). Fruit firmness was determined using a penetrometer with a 3.5-mm tip, soluble solid content was measured using a refractometer (Domínguez et al., 2004), and acidity by an automatic titration unit; results were expressed as grams citric acid per 100 g of fresh weight. To estimate the shelf life of ‘Santaclara’ fruits and compare it with the other cultivars, three times during the season, 500 g of randomly chosen ripe fruits per plot were maintained under controlled temperature (4°C) in a refrigerated chamber during 3 d followed by 2 d at room temperature; then calyx freshness and resistance to bruising were evaluated. Each trait was rated on a scale from 3 to 7, in which 3 is low calyx freshness and high bruising and 7 is high calyx freshness and not bruising (Table 3).

During the 2009 season, nutraceutical traits (Table 4) on ‘Santaclara’ fruits were compared with those of ‘Camarosa’, ‘Aguedilla’, ‘Fuentepina’, and ‘Sabrosa’. For the determination of nutraceutical compounds content, two assessments were run along the growing season: in mid-February and mid-April. Each time, a 250-g sample of randomly chosen ripe fruit per replication and plot was stored at −20°C. Total soluble phenolic compounds were measured in frozen samples using the Folin–Ciocalteu reagent (Slinkard and Singleton, 1977) and expressed as milligrams of gallic acid equivalent (GAE) per 100 g fresh weight. Total flavonoid content was measured by the aluminum chloride colorimetric assay (Dewanto et al., 2002) and expressed as milligrams of catechin equivalent (CE) per 100 g fresh weight. Total anthocyanins were determined following the procedure of Cheng and Breen (1991) and compared with values of ‘Camarosa’, ‘Aguedilla’ and ‘Fuentepina’ fruits. Total phenolic content of ‘Santaclara’ fruits was 110 mg GAE per 100 g fresh weight, similar to those recorded for the other cultivars. Total anthocyanin content reached 13.5 mg Pg-3-gluc per 100 g fresh weight, which was similar to that of ‘Camarosa’ and ‘Aguedilla’ and higher than that of ‘Sabrosa’ and ‘Fuentepina’. ‘Santaclara’ fruits showed the lowest flavonoid content with 8.8 mg CE per 100 g fresh weight. However, it is very important to point out that ‘Santaclara’ fruits had higher ascorbic acid content, 59.7 mg per 100 g fresh weight, significantly higher than any of the other tested cultivars.

Plants of ‘Santaclara’ and ‘Camarosa’ were inoculated artificially in the laboratory with Xanthomonas fragariae Kennedy & King, Phytophthora cactorum (Lebert & Cohn), Verticillium dahliae Kleb., and Podosphaera aphanis (Wallr.); the latter was also evaluated under field conditions. The resistance of ‘Santaclara’ to X. fragariae was greater than that observed for ‘Camarosa; the resistance to P. cactorum was similar; however, resistance to P. aphanis and V. dahliae was less than that of ‘Camarosa’ (De Cal, personal communication).

As a summary, the strengths of this new cultivar are its balanced agronomic and nutraceutical characteristics such as high early and total yields, large fruits and high fruit firmness, low percentage of misshapen fruits, and high ascorbic acid content. On the other hand, the weakness of ‘Santaclara’ is a medium to high percentage of second-class fruits (Table 1), mainly in early plantings.

**Availability**

The Andalusian Government (IFAPA-Junta de Andalucía), INIA, FNM, NTF, and FV have jointly applied for the inscription of ‘Santaclara’ in the Register of Commercial Strawberry Varieties (Spanish Plant Variety Office, application number 20090247).

Third parties interested in the propagation and/or commercial use of this cultivar should contact the authors of this article. E-mail: josem.lopez.aranda@juntaandalucia.es.

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### Table 4. Comparison of nutraceutical compounds content on ‘Santaclara’ fruits versus standard strawberry cultivars grown at Huelva (Spain) during the 2009 season.

| Cultivar | Phenolics content M/100 g FW | Flavonoids M/100 g FW | Anthocyanin M/100 g FW | Ascorbic acid M/100 g FW | Titratable acidity M/100 g FW |
|----------|----------------------------|----------------------|-----------------------|--------------------------|----------------------------|
| Santaclara | 110.0 a | 8.8 d | 13.5 a | 59.7 a | 0.72 c |
| Camarosa | 130.9 a | 12.7 b | 15.2 a | 47.2 b | 0.88 a |
| Sabrosa | 111.2 a | 12.5 b | 10.3 b | 48.7 b | 0.78 b |
| Aguedilla | 117.9 a | 18.3 a | 13.1 a | 50.7 b | 0.89 a |
| Fuentepina | 104.3 a | 11.3 c | 7.9 b | 48.8 b | 0.59 d |

*Expressed as milligrams of gallic acid equivalent/100 g fresh fruit.

*Expressed as milligrams of catechin equivalent/100 g fresh fruit.

*Expressed as milligrams of pelargonidin-3-glucose/100 g fresh fruit.

*Expressed as milligrams of pelargonidin-3-glucoside/100 g fresh fruit.

*Expressed as milligrams of ascorbic acid/100 g fresh fruit.

*Expressed as grams citric acid/100 g fresh weight.

*Within columns, mean values followed by different letters are significantly different at P ≤ 0.05 as determined by Fisher’s least significant difference test.
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