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‘Fontanilla’ Strawberry

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‘Fontanilla’ is a short-day strawberry (*Fragaria ×ananassa* Duch.) cultivar remarkable for its fruit firmness, low proportion of second-class fruit, and especially, very high fruit yield. Its early harvesting season is a key feature for commercial production on the southwestern coast of Spain and in similar temperate regions.

Helped by favourable weather conditions, good-quality water and sandy soils, together with the incorporation of advanced technology, Huelva—located on the southwestern coast of Spain—has become Europe’s leading producer of fresh-market strawberries. Fresh strawberry output in Huelva (93% to 95% of total Spanish production) is currently estimated at ≈290,000 t/year, grown on an area of ≈7,600 ha (FAOSTAT, 2014). In the 2013–14 crop season, the main cultivars were Splendor, Sabrina, and Fortuna.

Reflecting the economic and social significance of local fresh-market strawberry production, there has been growing research into strawberry breeding in Spain with a view to meeting the demands of both producers and consumers.

The aims of the Spanish strawberry breeding program, an initiative currently involving two public institutions—the Spanish National Agricultural Research Institute and the Andalusian Institute of Agricultural and Fishery Research and Training—and three private companies (*Nuevas Técnicas en Fresa*, *Fresas Nuevos Materiales*, and *Freshuelva Viveristas*), have changed over the years. Emphasis is now placed on the development of early, productive cultivars for the fresh market; the objective is to produce new cultivars with excellent organoleptic and nutraceutic properties which are suitable for shipping, are well adapted to local agro-environmental conditions in Huelva, and would thrive in production systems in which chemical soil treatments are not used.

Previous cultivars released from this program include ‘Andana’ (previously named ‘Calderona’) (Bartual et al., 1997), ‘Carisma’ (Bartual et al., 2002), ‘Marina’ (López-Aranda et al., 2004), ‘Medina’ (López-Aranda et al., 2005a), ‘Aguedilla’ (López-Aranda et al., 2005b), ‘Amiga’ (Soria et al., 2008), ‘Fuentepina’ (Soria et al., 2010), and ‘Santaclara’ (Domínguez et al., 2012).

Origin

The cultivar Fontanilla was selected from a 2006 cross between SE-1823-4 and ‘Sabrosa’ (Candonga™), and was tested as selection 2700-2. The female parent SE-1823-4, a line developed under our breeding program, is associated with high early and total yield, low percentage of second-class fruits and good fruit firmness. The male parent ‘Sabrosa’ was developed in Spain by Planasa (Plantas de Navarra, S.A.) and is remarkable for its excellent sensory properties: excellent flavor, attractive shape which is not prone to deformation, and high brix level. Both parents are well adapted to the Huelva area.

‘Fontanilla’ was propagated by runners at high-elevation nurseries in Nava de Arévalo, Castile-León, Spain (40°58′N, 4°46′W; altitude 850 m), and harvested in the third week of October for subsequent performance evaluations in experimental fields.

Description

‘Fontanilla’ is a short-day strawberry cultivar. In accordance with The International Union for the Protection of New Varieties of Plants descriptive guidelines (UPOV, 1995), it is vigorous and compact, with a semi-upright growth habit and a tendency to produce a moderate number of runners, similar to ‘Camarosa’, with medium anthocyanin coloration and medium pubescence. Leaves are large, with no blistering, and there are three medium-green, medium-glossy leaflets. The terminal leaflet is considerably longer than wide, with an obtuse base and serrate-to-crenate margins. Inflorescences are produced on long peduncles and are positioned above the foliage level. Flower size is medium and the calyx diameter is larger than the corolla. The corolla has five overlapping white petals, moderately shorter than broad. Fruits are very firm, long-wedge-shaped, and slightly longer than broad. Fruit size is large and constant throughout the fruiting season. Fully mature fruits are medium red and medium glossy (Fig. 1). Internal flesh is light red and the internal cavity is absent or small. The fruit surface is slightly uneven; achenes are inserted below the surface. The calyx is firmly attached to the fruit and is slightly larger than the diameter of the fruit. The fruit is pleasantly aromatic and tasty.

Flowering and ripening of ‘Fontanilla’ both occur early in the season, thus meeting the commercial requirements of Huelva growers.

Performance

During 2011 and 2012 crop seasons, ‘Fontanilla’ fruit production and quality were compared with those of three other well-adapted strawberry cultivars (Camarosa, Sabrosa, and Santaclara) in an experimental field located at Moguer (37°17′N) in the coastal area of Huelva (Spain). To reduce the presence of soil pathogens, soil was biofumigated and biosolarized (Domínguez et al., 2014) before planting. Chemical fumigants have never been applied to soil in this experimental field. During the third week of October of each year, bare root plants from high-elevation nurseries (Castille-Leon, Spain) were planted in three completely randomized plots of 50 plants each on two-row raised beds covered with black plastic; drip irrigation pipes were installed under the plastic. Each plot occupied a segment 6.25 m in length, with a separation of 50 cm between consecutive plots. Plants were spaced 0.25 × 0.25 m apart. In mid-November, plants were covered with large plastic (150 μ) tunnels (6.6 m wide × 3.5 m high × 70 m long). Between mid-November and mid-May, the fertilizer rate used was as follows: 175 kg N/ha, 77 kg P_2O_5/ha, 185 kg K_2O/ha, 85 kg CaO/ha, and 14 kg MgO/ha. Marketable fruits (first plus second fruit quality; i.e., first = healthy fruit well shaped with a weight above 14–15 g per unit, and second = healthy fruit that is shaped well and with a weight below 14–15 g per unit) were harvested and weighed 26 times from 10 Jan. to 17 May 2011 in the first crop season, and 28 times from 30 Dec. 2011 to 21 May 2012 in the second crop season. Individual fruit weight was calculated by dividing the total yield by the total number of harvested fruits. Each season, six fruits per plot were evaluated three times throughout the crop season (mid-February, mid-March, and mid-May) for external and internal color, internal cavity size, and fruit shape, and three to five fruits were evaluated five times throughout the crop season for firmness, soluble solid content, and ascorbic acid (vitamin C) content. Color (external and internal) and cavity size were subjectively rated on a visual scale (external color was rated on a scale from 1 to 7, where 1 is whitish yellow and 7 is blackish red, internal color was rated on a scale from 1 to 6, where 1 is whitish and 6 is dark red, and cavity size was rated on a scale from 1 to 3, where 1 is absent or small and 3 is large) (UPOV, 1995). Fruit firmness was measured using a penetrometer with a 3.5 mm tip, soluble solid content was

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measured using a digital refractometer (PR-32α; Atago, Japan), and ascorbic acid was measured with reflectometric test strips (Reflectoquant; Merck, Darmstadt, Germany). To estimate shelf life, at three points during the crop season 500 g of mature fruits per plot were kept in a cold chamber (4 °C) for three days and then at room temperature for two days before evaluating the percentage of rotten fruits. Additionally, three times in the course of the crop season, 250 g samples of randomly chosen ripe fruits per replication and plot were homogenized, and the purées obtained were frozen and stored at –20 °C until measurement of acidity, total phenolic compound content and antioxidant capacity. Acidity was measured by an automatic titration unit (Titroline Easy; Schott North America, Inc.) and results were expressed as g citric acid per 100 g fresh weight (FW); phenolics were analyzed using the Folin-Ciocalteu spectrophotometric method as modified by Slinkard and Singleton (1977), and results were expressed as milligrams of gallic acid equivalents (GAEs) per 100 g of FW of strawberry (mg GAE/100 g FW); antioxidant capacity was determined using the Trolox equivalent antioxidant capacity method (Re et al., 1999), and results were expressed as micromoles of Trolox equivalents per gram of FW of strawberry fruit (μmol TE/g FW). Cultivars were tested for resistance to *Colletotrichum acutatum*, causal agent of anthracnose disease. *C. acutatum* was grown on DIFCO potato dextrose agar plus 2 $g \cdot L^{-1}$ yeast extract under continuous fluorescent light for 7 d at 25 °C. Conidial suspensions were prepared and conidia concentration was adjusted to 10^4 conidia/mL. Ten strawberry plants per cultivar were inoculated by preplant dipping. After inoculation, plants were covered with plastics bags for 4 d in a growth chamber at 25 °C, exposed to a 16-h photoperiod. Control plants were dipped in sterile distilled water and incubated as described above (De los Santos et al., 2009). Symptoms were evaluated by weekly observations. Disease severity index was calculated according to 0–5 scale (Denoyes and Baudry, 1995). Cultivars were also screened for their relative resistance to powdery mildew (*Podosphaera aphanis* Wallr.) infection in glasshouse conditions. Strawberry plants (10 per cultivar) were transplanted into sterilized peat in 13-cm-diameter plastic pots where they were maintained, with one plant per pot, for the duration of the test. Plants were inoculated artificially by placing severely infected leaves between pots. Symptoms of powdery mildew infection on leaves were evaluated weekly. Disease severity index was calculated according to a 1–5 scale (Simpson, 1987).

Data were subjected to analysis of variance using Statistix 8.0 software (Analytical Software, Tallahassee, FL) and means were separated at the 0.05 level using Fisher's least significant difference test, or the Kruskal–Wallis comparison test (for subjective data). Percentages were arcsine transformed before statistical analysis.

Comparisons of yield and fruit quality for 'Fontanilla' and the other strawberry cultivars are shown in Table 1. 'Fontanilla' recorded the highest early and total yields in both crop seasons. Comparison of early yield values for 'Fontanilla' obtained here (457 and 633 g/plant, in 2011 and 2012; Table 1) with those recorded in the same experimental field in 2012 for early varieties 'Sabrina', 'Splendor', and 'Fortuna' (345, 388, and 406 g/plant, respectively; Medina et al., 2013) indicates that early yield was higher for 'Fontanilla'. Moreover, the percentage of second-class fruits was significantly lower for 'Fontanilla' than for 'Camarosa' in 2011 and 2012. Fruit production over the crop season in 2011 and 2012 is charted in Figures 2 and 3, respectively. 'Fontanilla' average fruit size was significantly greater than that of the other cultivars tested in 2011, but similar to that of 'Sabrosa' in 2012. 'Fontanilla' fruit firmness was higher than that observed for other cultivars except 'Santaclara'. Soluble solid content for 'Fontanilla' ranged from 6.1 in 2012 to 7.0 Brix in 2011; these values were lower than those recorded for 'Camarosa', 'Santaclara', and 'Sabrosa'; the latter showed the best value for this parameter.

Fig. 1. 'Fontanilla' strawberry fruits.

Table 1. Fruit production and fruit sensory and nutraceutic qualities for 'Fontanilla' versus standard strawberry cultivars grown in Huelva, Spain, over the 2011 and 2012 crop seasons.

Cultivar	Marketable early yield[z] (g/plant)	Marketable total yield[y] (g/plant)	Individual fruit wt (g/fruit)	Second quality fruit (%)	Fruit firmness (pressure g)	Soluble solid content (°Brix)	Titratable acidity (%)	Ascorbic acid[x]	Phenolic compounds[w]	Antioxidant capacity[v]
					2011					
Camarosa	341.2 b[u]	774.2 b	23.1 b	12.7 a	395 b	7.9 b	0.96 a	44.2 c	144.3 a	10.3 a
Fontanilla	456.5 a	1,077.9 a	29.2 a	7.2 b	435 a	7.0 c	0.77 a	45.7 bc	129.2 a	6.7 a
Sabrosa	207.0 c	642.6 c	21.6 b	10.6 a	420 ab	8.6 a	0.78 a	46.4 b	136.0 a	7.5 a
Santaclara	318.1 b	800.6 b	23.5 b	7.1 b	427 a	7.3 bc	0.75 a	48.3 a	129.6 a	8.2 a
					2012					
Camarosa	500.4 b	935.0 b	24.6 c	19.1 a	355 c	6.6 b	0.72 a	56.8 ab	105.9 a	4.8 a
Fontanilla	633.3 a	1,296.1 a	28.4 a	8.1 b	414 a	6.1 c	0.72 a	51.1 b	111.5 a	8.3 a
Sabrosa	434.6 c	904.5 b	26.7 ab	9.9 b	381 b	7.2 a	0.68 a	55.7 ab	107.0 a	7.0 a
Santaclara	488.9 b	857.7 b	25.2 bc	9.1 b	408 a	6.4 bc	0.71 a	62.1 a	120.0 a	6.0 a

[z]Early yield: from early January to late March.
[y]Total yield: from early January until late May.
[x]Expressed as mg ascorbic acid/100 g fresh weight (FW).
[w]Expresed as mg of gallic acid equivalent/100 g FW.
[v]Expresed as μmol Trolox equivalent/g FW.
[u]Within columns, means followed by different letters are significantly different at $P \leq 0.05$, as determined by Fisher's least significant difference test.

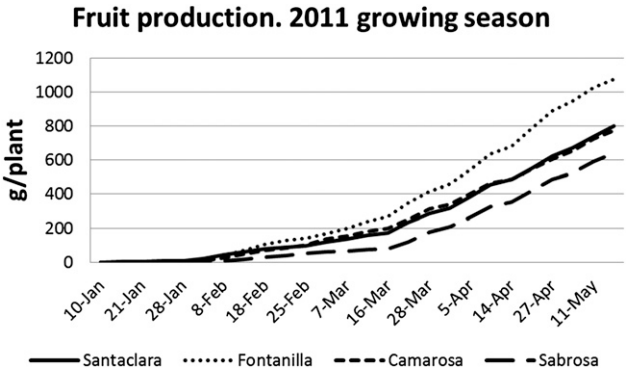

Fig. 2. Dynamics of 'Fontanilla' fruit ripening in 2011 crop season.

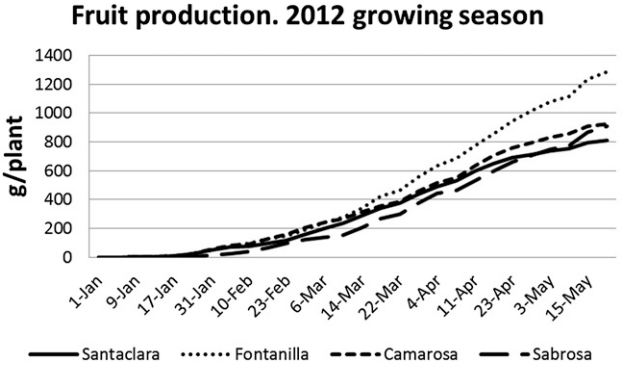

Fig. 3. Dynamics of 'Fontanilla' fruit ripening in 2012 crop season.

For acidity, no statistical differences were observed among cultivars in either study year. 'Fontanilla' showed good shelf life: mean percentage of rotten fruits was around 7%, i.e., similar to that recorded for the other cultivars (data not shown). Fully matured 'Fontanilla' fruits were lighter red, both on the outside and the inside, than 'Camarosa' and 'Sabrosa', and similar to 'Santaclara'. The internal cavity in 'Fontanilla' and 'Santaclar' was either absent or very weakly expressed, whilst in the other two cultivars it was larger (data not shown).

'Fontanilla' displayed a phenolic compound content ranging from 112 to 129 mg GAE per 100 g FW, and an antioxidant capacity of 6.7–8.3 µmol Trolox equivalent per gram FW; values were not statistically different from those recorded for the other cultivars. 'Fontanilla' fruit recorded the lowest ascorbic acid (Vitamin C) content in 2012 and an intermediate value in 2011; in all cases, 'Santaclara' displayed the highest values.

'Fontanilla' was found to be susceptible to *C. acutatum*, causal agent of anthracnose crown rot, whilst 'Fontanilla' and 'Sabrosa' were more resistant to *P. aphanis* than the other cultivars (data not shown).

Availability

The Andalusian Institute of Agricultural and Fishery Research and Training, Spanish National Agricultural Research Institute, *Fresas Nuevos Materiales*, *Nuevas Técnicas en Fresa*, and *Freshuelva Viveristas* have jointly applied for this cultivar to be listed in the Register of Commercial Strawberry Varieties (Spanish Plant Variety Office, application number 2011/170). Parties interested in propagating this cultivar should contact *Fresas Nuevos Materiales*, Plaza Puerto Moral 2, 21007 Huelva, Spain.

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