‘Nazaret’ Strawberry

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The growing economic and social significance of strawberry (*Fragaria* × *ananassa* Duch.) production in Spain has led public and private institutions to increase breeding efforts in an attempt to obtain new cultivars that are well-adapted to the growing conditions in Huelva, the main strawberry-cropping area in Europe. Currently, numerous public and private strawberry-breeding programs are aiming to develop and release cultivars that are well-adapted to the agronomic and environmental conditions of this area. In the last 10 years, the varietal spectrum has gone from a practically monovarietal cultivation, with more than 80% of the area planted with the cultivar Camarosa (López-Aranda 2008), to a multivarietal culture system; currently, there are more than 20 cultivars, developed by different breeding programs, available to farmers (Table 1).

So far, the Spanish public breeding program has released 10 short-day cultivars: ‘Andana’, ‘Carisma’, ‘Marina’, ‘Medina’, ‘Amiga’, ‘Aguedilla’, ‘Fuentepina’, ‘Santaclara’, ‘Fontanilla’ (renamed as ‘Sarito’), and ‘Nazaret’ (Domínguez et al., 2012, 2015; López-Aranda et al., 2004, 2005a, 2005b; Soria et al., 2008, 2010).

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‘Nazaret’ is the last cultivar released jointly by two Spanish public institutions, the Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria and the Instituto de Investigación y Formación Agraria y Pesquera (IFAPA), as well as the private partners Fresas Nuevos Materiales S.A., Nuevas Técnicas en Fresa, and Freshuelva Viveristas.

The short-day cultivar Nazaret is noted for its high early and overall fruit yields; its greater yield at the beginning of the season makes it competitive with other cultivars currently used in the Huelva production area. Moreover, its acceptable fruit firmness is essential for long-distance shipment.

The name ‘Nazaret’ is that of a well-known location in Moguer, Huelva (Spain), made famous by the works of the Spanish writer Juan Ramón Jiménez, winner of the 1956 Nobel Prize for Literature, who spent his young years in the strawberry-production area around this city.

Origin

‘Nazaret’ was first selected in 2009 as 3022-2, from a cross between the IFAPA breeding lines 1806-1 as mother, and 2340-2 as father, produced in 2008, on the basis of their performance under local conditions. The female parent is an accession with early production of very firm fruits with a high soluble solids content. 2340-2 was chosen as male parent for its outstanding total production. Both parents are vigorous, short-day breeding lines well-adapted to the Huelva area. ‘Nazaret’ was vegetatively propagated for performance evaluations at high-elevation nurseries in Castille-Leon, Northeast Spain (900–1000 m altitude). Its clones were later evaluated together with other well-adapted cultivars in replicated plot trials in a state-run experimental field in the strawberry-producing area of Moguer (Huelva; 37°17' N).

Description

‘Nazaret’ has been described following the International Union for the Protection of New Varieties of Plants guidelines (UPOV, 1995). It is a short-day cultivar with vigorous plants that show a semiupright growth habit and a tendency to produce runners with weak anthocyanin coloration and sparse pubes-

cence. The leaves are large, with three medium green and medium glossy leaflets with strong blistering. The terminal leaflet is much longer than its width, with an obtuse base and serrate to crenate margins. Inflorescences with many flowers are produced on long peduncles, and flowers open at the level of the canopy. Flower size is medium, and the calyx diameter is greater than the corolla. The corolla has five overlapping white petals that are broader than long. The berries (Fig. 1), which have a consistent conical shape, are medium size, dark red on the outside, and with medium-red flesh. The fruit surface is slightly uneven, and achenes are inserted below the surface. The calyx is moderately attached to the fruit, and its diameter is similar to that of the fruit. The fruit is tasty and pleasantly aromatic. ‘Nazaret’ is a productive cultivar with very high early and total yields of first quality fruit; the percentage of second class fruit is low. Fruit ripening occurs early in the season.

Performance

During the crop seasons 2012 and 2013, fruit production (Table 2) and quality (Table 3) of ‘Nazaret’ were compared with two other well-adapted strawberry cultivars (Candonga® and ‘Fortuna’) at an experimental field in the strawberry production area of Moguer. To reduce the presence of soil pathogens, the soil was solarized and biofumigated (Medina-Mínguez, 2002) before planting. During the last week of October of each year, bare-root plants were planted on two-row raised beds covered with black plastic in a complete randomized block design of 50 plants per replication (three replications). 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). Marketable fruits, including both first quality (no misshapen fruits of ≥17 g) and second quality (no misshapen fruits among 10–17 g), were harvested and weighed, once or twice a week, starting in early January. Individual fruit weight was calculated by dividing the total yield by the total number of harvested fruit. Six ripe fruits per plot were evaluated three times throughout the cropping season (mid-February, mid-March, and mid-May) for external and internal color, internal cavity size, firmness, and content of soluble solids. Color and cavity size were subjectively rated on a visual scale (Table 3). Fruit firmness was determined using a penetrometer with a 3.5-mm tip, the soluble solid content was measured using a refractometer (R.A.E.A. Fresas, 2004), and for total ascorbic acid (vitamin C), reflectometric test strips (Reflectoquant; Merck, Darmstadt, Germany) were used. To determine the content of nutraceutical compounds, two measures were taken during the growing season: mid-February and mid-April. Total soluble phenolic compounds were measured in strawberry juice, using the Folin-Ciocalteu reagent (Slinkard and Singleton, 1977), total anthocyanin content was measured with the pH differential

Table 1. Strawberry varietal distribution (%) at Huelva, Spain: Crop season 2017–18.

Variety	% Plants	Breeding program
Fortuna	37.0	University of Florida
Rociera FNM	19.3	Fresas Nuevos Materiales
Victory	11.8	Plant Sciences
Primoris FNM	8.1	Fresas Nuevos Materiales
San Andreas	6.8	University of California (UC Davis)
Rabida FNM	6.3	Fresas Nuevos Materiales
Calinda	2.7	Freshforward
Viva Patricia	1.7	Edward Vinson
Splendor	0.9	Plant Sciences
D Marquis	0.7	Driscoll's
Candonga	0.5	Planasa
Honor	0.3	Plant Sciences
Liberty	0.3	Plant Sciences
Pelaluma	0.3	University of California
Frontera	0.3	University of California
D Lusa	0.3	Driscoll's
Sabrina	0.3	Planasa
Candy FNM	0.3	Fresas Nuevos Materiales
D Magdalena	0.2	Driscoll's
Flavia	0.2	Consorzio Italiano Vivaisti
BG63024	0.2	Plant Sciences
Calderon WB	0.2	Masiá Ciscar
Melissa	0.2	Nova Siri
Confidence	0.2	Plant Sciences
Camarosa	0.2	University of California

FNM = Fresas Nuevos Materiales S.A.

Fig. 1. Fruits of 'Nazaret' strawberry.

absorbance method (Cheng and Breen, 1991), and total antioxidant capacity was evaluated according to Trolox-equivalent antioxidant capacity assay (Re et al., 1999). 'Nazaret' susceptibility to *Verticillium dahliae*, *Phytophthora cactorum*, *Podosphaera aphanis*, *Macrophomina phaseolina*, and *Colletotrichum acutatum* was evaluated such as described in Avilés et al. (2009), De los Santos et al. (2009), Redondo et al. (2009), and Recuenco et al. (2005). 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). The percentage of second-quality fruit was arcsine transformed before statistical analysis.

Results for 'Nazaret' yield and fruit quality parameters in replicated trials are provided in Tables 2 and 3, respectively. 'Nazaret' had greater early and total yields than 'Fortuna' and Candonga in 2012 and 2013 and a low percentage of second-quality fruit. During both crop seasons, fruit size of 'Nazaret' was similar to that of 'Fortuna' and Candonga (no significant differences were observed). The fruit firmness of the three cultivars ranged from 25.1 to 28.0 kg·cm⁻² and from 26.6 to 30.3 kg·cm⁻² in 2012 and 2013, respectively; no significant differences were observed in either crop season. Soluble solid content for 'Nazaret' was significantly lower than that of Candonga in 2012 (7.4 and 8.4 °Brix, respectively), and similar to those of Candonga and 'Fortuna' in 2013. For acidity and sugar/acid ratio, no statistical differences were observed among cultivars in 2012; however, in 2013, 'Nazaret' fruit were more acidic and had a lower ratio of sugar/acidity than the other cultivars. In 2012 'Nazaret' fruit ascorbic acid (vitamin C) content was similar to all other cultivars. In 2013, 'Nazaret' ascorbic acid content was similar to Candonga's but statistically greater than 'Fortuna's' (Table 2).

'Nazaret' displayed a fruit phenolic compound content ranging from 92 to 119 mg gallic acid equivalent per 100-g fresh weight, and an anthocyanin content ranged from 9.7 to 20.7 mg Per-3-glu equivalent per 100-g fresh weight; values were not statistically different from those recorded for the other cultivars ('Fortuna' and Candonga). The

Table 2. Fruit production of 'Nazaret' versus standard strawberry cultivars grown at Huelva (Spain) during the crop seasons 2012 and 2013.

Cultivar	Early yield ^z		Total yield		Wt/fruit (g/fruit)	Firmness (kg·cm ⁻²)	Total soluble solids (°Brix)	Titratable acidity (%)	Ascorbic acid (mg/100 g FW)
	Marketable (g/plant)	Second quality (%)	Marketable (g/plant)	Second quality ^y (%)					
2012									
Candonga	435 b ^x	3.5 b	905 b	9.9 ab	28.0	5.39	8.4 a	0.73	55.7
Fortuna	625 a	8.7 a	891 b	13.9 a	25.1	4.99	7.6 b	0.61	49.0
Nazaret	727 a	3.1 b	1227 a	6.6 b	26.7	5.06	7.4 b	0.68	51.2
2013									
Candonga	319 b	2.1 b	936	14.9	26.7	4.86	7.7 a	0.74 b	53.2 a
Fortuna	505 a	5.4 a	886	11.7	26.6	4.78	6.6 b	0.59 c	43.2 b
Nazaret	566 a	1.7 b	1181	9.8	30.3	4.69	7.2 ab	0.83 a	56.7 a

²Early yield: up to end of March.³Second quality: marketable fruits among 10–17 g.^xWithin columns, means followed by different letters are significantly different at $P \leq 0.05$, as determined by Fisher's least significant difference test.

Table 3. Fruit quality of 'Nazaret' versus standard strawberry cultivars grown at Huelva (Spain) during the crop seasons 2012 and 2013.

Cultivar	External color ^z	Internal color ^z	Internal cavity size ^y
2012			
Candonga	5.4	4.1	5.0 ab ^x
Fortuna	5.6	4.6	4.1 b
Nazaret	5.6	4.1	6.3 a
2013			
Candonga	6.4	5.3	5.0 ab
Fortuna	6.2	4.3	3.0 b
Nazaret	6.0	5.1	6.3 a

^zRated on a scale from 1 to 9, where 1 = light red and 9 = deep red.

^yRated on a scale from 1 to 9, where 1 = absent and 9 = large internal cavity.

^xFor each year, within columns, means followed by different letters are significantly different at $P \leq 0.05$, as determined by the Kruskal–Wallis comparison test.

average antioxidant capacity of 'Nazaret' (14.7 μmol Trolox equivalent per gram fresh weight) was statistically similar to 'Fortuna' (16.2) and lower than Candonga (18.5).

The external and internal color of fully mature 'Nazaret' fruits remained stable throughout the crop season; fruits were medium red on the outside and orange–red to red on the inside, similar to the other cultivars tested. The size of the internal cavity in the fruit was quite conspicuous; similar to that of Candonga and significantly larger than that of 'Fortuna' (Table 3).

Postharvest testing, carried out three times along the 2014 harvest season, showed that 'Nazaret' fruit has a good shelf life; after 3 d on cold storage camera at 4 °C and 2 d at room temperature, the percentage of rotten fruits of 'Nazaret' (8.8%) was not significantly different from that of 'Fortuna' (10.9%).

'Nazaret' was more susceptible than Candonga and 'Fortuna' to powdery mildew, caused by *Podosphaera aphanis* (Wallr.), whereas the resistance of 'Nazaret' to *Colletotrichum acutatum* Simmonds was greater than that observed for Candonga and similar than that observed for 'Fortuna'. Susceptibility to *Macrophomina phaseolina* was similar. Resistance testing against *Phytophthora cactorum* (Lebert & Cohn) and *Verticillium dahliae* Kleb. indicated that 'Nazaret', 'Camarosa', and Candonga have similar levels of resistance.

As a summary, the strength of this new cultivar is its balanced yield and quality traits, such as good early and total yield, low percentage of second-class fruit, and high fruit size, fruit firmness, and ascorbic acid content.

Availability

The Andalusian Government (IFAPA Junta de Andalucía), Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Fresas Nuevos Materiales S.A., Nuevas Técnicas en Fresa, and Freshuelva Viveristas have jointly applied for an inscription in the Register of Commercial Strawberry Varieties (Spanish Plant Variety Office, application number 20150112).

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