‘Pacal’ Orange Casaba: A Multi-disease Resistant, Specialty Melon Cultivar from Texas A&M AgriLife Research

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Melons (*Cucumis melo* L.) are among the most popular and nutritious fruiting vegetables in the United States, with the lowest cost per pound to the consumer. The high levels of vitamin C, carotenoids, folate, potassium, and superoxide dismutase (SOD) provide valuable antioxidant and other human health-promoting properties (Lester, 2008; Lester et al., 2009). Hence melons have become an important component of fresh-cut food products where convenience, quality, and safety are in high demand. Quantifiable consumer preference traits, such as taste (sweetness), texture (firmness), or flavor (aroma), all contribute to the popularity of melons as components of the whole-fruit and fresh-cut sectors. These consumer satisfaction components are strongly influenced by genetic as well as environmental and production management factors (Lester et al., 2007). Continued breeding efforts to improve consumer preference, as well as retail and production suitability traits such as shelf life and disease resistance, have resulted in diverse melon types. Many of these specialty melons are uniquely flavorful and often receive higher prices for growers and retailers (Guan et al., 2013). The rapid growth of farmers' markets and other direct marketing techniques have also driven demand for more types of specialty melons or better tasting cultivars.

Melon production also represents an important economic component of the U.S. vegetable sector (Cantliffe et al., 2007). Orange-fleshed melons such as cantaloupes are the most popular melons in the United States. In 2014, 63,200 acres of cantaloupes were harvested with a production value of

\$327.9 million, followed by honeydew melons grown on 14,450 acres with a value of \$88.6 million (USDA-NASS, 2014). Developing new orange-fleshed varieties of honeydew melons with a high nutritional value could expand the economic revenue for producers.

Orange-fleshed inodorus melons present many advantages over cantaloupe melons such as better flesh texture (firmness), shelf life, ability to withstand lower storage temperatures, reduced susceptibility to surface microbial contamination, higher sugar content, improved disease resistance, higher yields, and better consumer acceptance (Fleshman et al., 2011; Hodges and Lester, 2006; Johnstone et al., 2008; Laur and Tian, 2011; Lester, 2008; Lester and Crosby, 2002; Lester et al., 2007; Saftner et al., 2006).

Origin

‘Pacal’ originated from a cross of ‘TAM Dew Improved’ with melon line ‘ms-3’ (McCreight and Elmstrom, 1984). F₂ progeny plants were evaluated for resistance to powdery (*Podosphaera xanthii*) and downy (*Pseudoperonospora cubensis*) mildews, and fruit quality during the fall season of 1999 at Weslaco, TX. A single plant selection was made with high resistance to both diseases compared with other susceptible F₂ progeny. This plant also produced a very high-quality orange-fleshed, elongated casaba-type fruit. This open-pollinated F₃ seed was planted again during the spring of 2000 at Weslaco and several progeny plants were identified with the same disease resistance and fruit quality attributes, including a white rind, free from netting, and with the characteristic casaba wrinkling near the stem end. Cuttings were made of these plants and allowed to self-pollinate in the greenhouse. This F₄ generation seed was bulked and planted in

isolation plots during the spring of 2001. Selection was again carried out for resistance to powdery and downy mildews. Due to heavy rains and high humidity, extensive alternaria leaf spot (*Alternaria cucumerina*) was also observed in the field plots, allowing selection for resistance to this disease. ‘TAM Dew Improved’ and ‘TAM Mayan’ were used as checks for resistance to all three diseases in separate field plots. ‘TAM Dew Improved’ is an appropriate resistant control used for evaluation of *Alternaria* resistance (Thomas and Caniglia, 1997). After four more generations of selection in isolation plots (years 2004 to 2007), desirable uniformity for disease resistance and fruit quality was obtained.

Field Performance

Seed of the F₈ generation were planted in test plots at three Texas locations to verify uniformity and adaptation. At Weslaco and Uvalde, yield, disease resistance, and quality data were recorded from replicated plots (Tables 1 and 2). Plants were grown in beds at 0.3 m apart and 2.0 m between beds covered with black plastic mulch. Other standard commercial melon production practices, including subsurface drip irrigation, were used. No fungicides were applied, but several applications of insecticides were used to control whiteflies. Yield was calculated from three 5-m replicated plots and extrapolated to the hectare. Mildew ratings were based on an average rating of the 10 most symptomatic leaves from each plot. These averages were rounded up to the nearest whole number (Table 1). Fruit quality traits were based on six fruits from each of three replicated plots. Total soluble solids (TSS) were measured with a standard refractometer (Atago, Japan), whereas beta-carotene was measured by the spectrophotometric method of Sadler et al. (1990), with slight modifications. Yields were higher at Uvalde for all cultivars due to larger fruit sizes and less disease pressure. Most ‘Pacal’ fruits reached size 4+ (4 melons fit in a box) at Uvalde, whereas most fruits at Weslaco were size 6 (6 melons fit in a box). Because of a large, dry seed cavity, the fruits of ‘Pacal’ do not necessarily weigh more than typical size 5 or 6 honeydews. The current F₁₀ generation appears to be uniform for resistance to the three leaf pathogens and fusarium wilt (0, 2), based on observations at several locations with infested soils. Though controlled inoculations with fusarium wilt were not carried out, the fact that both parents carried the *Fom-1* gene, suggests that the field resistance observed is likely due to the presence of this single, dominant gene. At College Station, the only disease observed was sporadic fusarium wilt on ‘Orange Dew’ but none on ‘Pacal’ or ‘TAM Dew’. No yield or quality data were recorded due to excessive rains destroying all fruit in the plots.

Description

The mature fruit of ‘Pacal’ is large to very large, ellipsoid, with a creamy white,

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Table 1. Fruit production and quality characteristics of 'Pacal' compared with three other inodorus cultivars at Weslaco, TX.

	Pacal	Orange Dew	TAM Dew	Caroline
Fruit size ^z	4–6	12–15	9–12	4–6
Fruit thickness (cm) ^y	5.4 a	4.1 b	5.0 a	5.5 a
Yield (boxes/ha) ^x	2,040 a	1,320 b	1,480 b	2,060 a
Total soluble solids (TSS)	15.6 a	12.5 b	14.9 a	11.8 b
Beta-carotene (µg·g ⁻¹)	20.2 b	36.2 a	0.5 c	0 c
Closed seed cavity (%) ^w	50	90	80	50
Powdery mildew rating ^v	1	5	0	5
Downy mildew rating ^u	1	5	1	3
Days to maturity	85	80	80	78

^zNumber of fruits which fit into a standard size melon box.

^yAverage distance between rind and seed cavity/placenta.

^xBased on a standard 22-kg melon box.

^wAmount of airspace, where 100% closed is no airspace, 50% is half airspace and half placenta/seed, etc.

^uBased on a scale from 0 to 5, with 0 = no colonies present, 1 = colonies on <10% of the leaf surface, 2 = colonies on 20% to 30% of surface, 3 = colonies on >30% of surface, 4 = colonies on 100% of adaxial surface, 5 = dead leaf.

^vBased on a scale from 0 to 5, with 0 = no leaf necrosis, 1 = yellowing/necrosis on <10% of leaf surface, 2 = yellowing/necrosis on 10% to 20% of leaf surface, 3 = yellowing/necrosis on >20% of leaf surface, 4 = yellowing/necrosis on >30% of leaf surface, 5 = dead or completely yellow leaf.

Mean separation within rows by least significant difference, $P \leq 0.05$. Means followed by the same letters are not significantly different.

Table 2. Fruit production and quality characteristics of 'Pacal' compared with three other inodorus cultivars at Uvalde, TX.

	Pacal	Orange Dew	TAM Dew	Boule d' Or
Fruit size	4	9–12	9–12	4–6
Fruit thickness (cm) ^z	6.2 a	4.9 b	5.3 ab	6.0 a
Yield (boxes/ha) ^y	4,880 a	1,940 c	1,980 c	2,730 b
Total soluble solids	12.4 a	12.6 a	13.1 a	12.8 a
Beta-carotene (µg·g ⁻¹)	11.5 b	19.5 a	0 c	0 c
Close seed cavity (%)	30	90	80	60
Powdery mildew rating ^x	0	3	0	3
Downy mildew rating ^w	0	3	0	2
Days to maturity	88	82	85	92

^zAverage distance between rind and seed cavity/placenta.

^yBased on a standard 22-kg melon box.

^wBased on a scale from 0 to 5, with 0 = no colonies present, 1 = colonies on <10% of the leaf surface, 2 = colonies on 20% to 30% of surface, 3 = colonies on >30% of surface, 4 = colonies on 100% of adaxial surface, 5 = dead leaf.

^xBased on a scale from 0 to 5, with 0 = no leaf necrosis, 1 = yellowing/necrosis on <10% of leaf surface, 2 = yellowing/necrosis on 10% to 20% of leaf surface, 3 = yellowing/necrosis on >20% of leaf surface, 4 = yellowing/necrosis on >30% of leaf surface, 5 = dead or completely yellow leaf.

Mean separation within rows by LSD, $P \leq 0.05$. Means followed by the same letter are not significantly different.

Fig. 1. 'Pacal' orange casaba melon: (A) Mature fruit, (B) interior of fruit, (C) healthy 'Pacal' leaves (top) compared with leaves of susceptible variety 'Caroline' (bottom) under severe powdery mildew infestation.

net-free rind, exhibiting characteristic casaba wrinkling (Fig. 1). The rind turns a pale yellow color when allowed to reach full slip and the thick orange flesh is extremely sweet (12–16 °Brix) with a unique flavor. Total soluble solids have been consistently higher

(12–16 °Brix) than other cultivars at Weslaco over the past three seasons, whereas at Uvalde, TSS were lower than 'Orange Dew'. Beta-carotene content of 'Pacal' was less at both Weslaco and Uvalde than 'Orange Dew', but much higher than

traditional, white-fleshed casaba melons, which have almost none. In addition, 'Pacal' was found to have substantially higher SOD activity than other melons (Lester et al., 2009). Yields are equal or superior to other honeydew/casaba cultivars, with plants exhibiting superior disease resistance (Table 1). In trials at Weslaco, Pacal was the only cultivar besides TAM Dew, out of 22 commercial honeydew and casaba entries, with a high level of resistance to powdery mildew (presumably race 2). It is also resistant to *Alternaria*, downy mildew, and fusarium wilt. In addition, the vigorous vine produces over an extended period. The excellent shelf life of the fruit makes 'Pacal' suitable for production in both spring and fall seasons in south Texas. In addition, 'Pacal' performed well in a commercial organic farm (near Austin, TX; Crosby, unpublished data), where its disease resistance and quality traits are even more important than in conventional systems. New replicated trials are being arranged with several organic growers with a strong market for specialty melons.

Availability

Breeder's seed will be maintained by the Vegetable and Fruit Improvement Center at Texas A&M. This open-pollinated cultivar may be licensed through Texas A&M AgriLife Research for commercial seed production.

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