

Fruit Quality Evaluations of Avocado Cultivars for Subtropical Texas

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Abstract. Thirty-six cultivars of avocado (*Persea americana* Miller) from Florida, California, and Texas were planted for evaluation in the Lower Rio Grande Valley of Texas. Twenty-five of these were evaluated for fruit characteristics and fruit quality before the December, 1889 freeze severely damaged the trees. Criteria for selecting cultivars for evaluation included potential cold tolerance similar or better than 'Lula', with the objective of finding selections with commercial market potential capable of surviving temperatures to the mid and low twenties. The results suggest potential for 'Ettinger' and an early September maturing selection WA-2-3-27; although the latter was precocious it was low yielding in the first production year. Selections WB-3-14-14, 'Nesbitt', 'Taylor', and 'Reed' also warrant further evaluation. All these selections were low in vascular fiber strings, had a nutty and buttery flavor, had low to no incidence of anthracnose (*Colletotrichum gloeosporioides* Penz.), weighed 255 to 400g (9 to 14 ounces), and except for WA-2-3-27 had medium-high to high yields. Oil content averaged consistently at 14%. A relationship between anthracnose resistance and peel thickness among cultivars was noted. Although none of the trees were able to withstand -8C (17F) degrees during the 1989 December freeze without severe injury, several cultivars like 'Ettinger' have more cold tolerance than 'Lula'. These cultivars can survive temperatures to the -3 or -4C (mid-twenties F) and should be able to bear fruit most years in south Texas.

Abstracto. Treinta y seis cultivos de aguacate (*Persea americana* Miller) de Florida, California, y Tejas se sembraron para ser evaluados en la parte baja del Valle del Río Bravo en Tejas. Veinticinco de estos fueron evaluados en cuanto a las características y calidad del fruto antes de que la helada de diciembre de 1989 dañara severamente los árboles. El criterio para seleccionar los cultivos por evaluar incluyó el potencial de tolerar el frío similar o mejor que 'Lula', con el objetivo de encontrar selecciones con potencial comercial capaces de sobrevivir temperaturas fahrenheit en los medios y bajos veinte. Los resultados sugirieron potencial para 'Ettinger' y una selección con madurez en los primeros de septiembre WA-2-3-27; aunque el último fue precoz, fue de bajo rendimiento en el primer año de producción. Las selecciones WB-3-14-14, 'Nesbitt', 'Taylor', y 'Reed' también merecen más evaluación. Todas estas selecciones fueron bajas en hilos de fibra vascular, tuvieron un sabor a nuez y mantequilla, tuvieron un incidente bajo o no existente de antracnosis (*Colletotrichum gloeosporioides* Penz.), pesaron de 255 a 400g (9 a 14 onzas), y excepto por WA-2-3-27 tuvieron rendimiento de medio alto a alto. El promedio del contenido de aceite fue consistentemente 14%. Una relación entre la resistencia a la antracnosis y grosor de la cáscara entre los cultivos fue notorio. Aunque ninguno de los árboles fue capaz de soportar -8C (17F) grados durante la helada de diciembre 1989 sin adquirir daños severos, varios cultivos como 'Ettinger' tienen más tolerancia al frío que 'Lula'. Estos cultivos pueden sobrevivir temperaturas hasta -3 o -4C (medios veinte F) y deben poder dar fruto la mayoría de los años en el sur de Tejas.

Avocados (*Persea americana* Miller) have always been of interest to growers in the subtropical climate of the Lower Rio Grande Valley of Texas. Approximately 500 acres of the cultivar 'Lula' existed in several small plantings in the Lower Rio Grande Valley before the 1983 freeze. Although 'Lula' is the most susceptible commercial avocado cultivar to scab (*Sphaceloma Perseae*) in Florida (Burnett, 1974; Malo and Campbell, 1972) it has been grown successfully in the Lower Rio Grande Valley without the need for control of scab, other diseases, or insect pests.

Earlier research at the Texas A&M Research & Extension Center at Weslaco, Texas had shown that 'Lula' was the only cultivar recommended for field planting (Lyons and Maxwell, 1973; Maxwell, 1971). Unfortunately temperatures below -2.2°C (28°F) occur on an average of every 4 to 5 years in the Lower Rio Grande and 'Lula' is damaged after several hours at and below -2.2° (Lyons and Maxwell, 1973). Therefore, the need remained to continue selecting and testing additional avocado cultivars that offered more cold tolerance and have a potential for local fresh market sales. Research supports the feasibility of breeding cold-tolerant cultivars of high horticultural quality (Knight, 1974). Krezdorn (1970) evaluated selections of Mexican race avocados for cold tolerance and concluded the selections with commercial potential appeared to be Guatemalan x Mexican hybrids (Krezdorn, 1975). The fruit quality of some Mexican race

avocados is acceptable, but none of this group produce fruit sufficiently large or, thick skinned enough, or with anthracnose resistance (Knight, 1974) to be commercially useful.

A test planting was established at the Texas Agricultural Research and Extension Center, Weslaco, Texas in 1986 using selected Mexican race avocados and cultivars of other origins. The objective of the test was to select avocados with commercial market potential. Many of the selections began fruiting in 1988, and preliminary evaluations were made. A more complete record of fruit characteristics and fruit quality was taken in 1989.

Materials and Methods

Avocado budwood of selected cultivars and clonal selections believed to have similar or better cold tolerance than 'Lula', and many capable of surviving temperatures at -3 to -4C (mid-twenties F) were obtained from the USDA Subtropical Horticultural Research Station at Miami, Florida and the University of California at Riverside. In addition, local selections from south Texas were included. Characteristics evaluated were cold hardiness, fruit quality, fruit size and other horticultural characteristics.

Scion wood was received from Florida in January 1986 and cleft grafted to container-grown seedling rootstocks of 'Waldin' and 'Lula'. During the Autumn of 1986, the plants were established in the field at the Texas Agricultural Experi-

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ment Station, Weslaco, Texas. Scion wood from California was received in Spring of 1987, and grafted trees were field-planted that autumn.

The experimental design for the planting was six replications of single-tree plots with each scion cultivar on the two rootstocks. No differences were found between rootstocks and the data were combined for analysis of fruit characteristics.

Several cultivars and selections produced fruit in 1988. Preliminary evaluations of the fruit and trees were made in 1988 and a complete data set was taken on fruit characteristics and fruit quality in 1989 from trees in production. As a result of delays in receiving scion wood and obtaining authorization to propagate patented plant material from California, several cultivars were not in production at the time of evaluation. The cultivars analyzed were: 'Lula', 'Bacon', 'Nesbitt', 'Taylor', 'Fuerte', 'Reed', 'Young #1', 'Young #2', 'Gainesville', 'Kizzia', 'Bernecker', 'Tonnage', 'Tower #2', 'Hass', 'Beta', 'Ettinger', 'Bassage', 'Alboyce', and breeding lines WB3-13-7, WA2-3-27, WB3-14-14, WF3-3-11, WB3-13-10, WB3-13-2 and WA2-2-21. All trees had an adequate to good crop of fruit for evaluating fruit characteristics in 1989. Data acquisition for 1989 was completed from most of the cultivars before a freeze in December.

Data on characteristics of harvested fruit were recorded three times per week from a sample of five representative fruit per tree. Cultivar maturity dates were established by first sampling fruit several weeks before anticipated maturity. Actual maturity dates were determined when the harvested fruit sample softened and ripened without spoilage in a room maintained at 25°C (77°F). The presence or absence of anthracnose on fruits was noted while on the tree and during ripening. Oil content of the flesh was determined at a time considered to be midway through the anticipated maturity dates for the cultivar. It was recorded as grams of oil per 100 grams of dried flesh according to the AOAC standard ether extraction method (A.O.A.C., 1984). All color, fiber, shape and anthracnose determinations were by observation by the authors. Flavor was determined by the presence of the attribute by the authors.

Results

Preliminary evaluations of fruit in 1988 revealed two cultivars which had potential to satisfy marketing criteria. The complex Mexican hybrids (Table 1) 'Ettinger' and selection WA-2-3-27 had good quality, buttery flavor, medium to small seed, green skin, and 256 to 312 g (9 to 11 ounces) and shaped like 'Lula'. The anise-scented leaves indicated a hybrid with the cold tolerant Mexican Race type avocado. 'Ettinger' originated in Israel, where it had been grown commercially, as a seedling of unknown parentage, and WA-2-3-27 originated at the USDA Miami station as a seedling of 'Brooksville' Mexican (M-18686) open pollinated.

Results from 1989 (Tables 1 & 2) supported the preliminary conclusion that 'Ettinger' and possibly selection WA-2-3-27 were potential early season maturing cultivars, although

WA-2-3-27 was rated as a low producer. Additional clones WB-3-14-14, 'Nesbitt', 'Taylor', and 'Reed' were found to be worth consideration and warrant close attention and further evaluation. The weight of fruit from all of these cultivars and selections was in the range of 255 to 400 g (9 to 14 ounces). They had high to medium-high yield, good tolerance or resistance to anthracnose, a nutty-buttery flavor, and were low in vascular fiber strings.

'Ettinger' and WB-3-14-14 matured considerably earlier in the season than did 'Lula'. 'Ettinger' held well on the tree from early October through November, but began to drop fruit in mid-December. Several cultivars and selections were observed to be dropping fruit and softening on the tree at the end of the maturity dates listed in Table 1. The cultivars and selections dropping fruit were 'Kizzia', WB-3-14-14, 'Tonnage', 'Tower #2', 'Beta', 'Bassage', and 'Bacon'.

Yield is important in evaluating avocado cultivars, but only after identifying a cultivar with high quality fruit and a time of maturity that satisfies an opening in the market. Yield in this evaluation was rated as low, medium, or high based on the crop load on the tree and considering the size of the individual tree. Both 'Ettinger' and WB-3-14-14 set an extremely heavy crop in 1989. It is important to realize that these were 3 to 4-year-old trees with their first crop, although some trees had set a limited amount of fruit the previous year. Yield ratings in this study only indicate the potential of the tree to set and mature a crop and may not be representative of mature trees.

Seeds have always been too large in avocados. The amount of edible flesh around the seed is an important consideration in evaluating any avocado fruit. Selection WA-2-3-27 and 'Alboyce' had the highest percentage of edible flesh per fruit (88%), although all cultivars and selections were acceptable except for 'Gainesville', WB-3-13-10, and possibly WA-2-2-21.

Data obtained when measuring peel thickness indicated a relationship with the presence of anthracnose (*Colletotrichum gloeosporioides* Penz.). When peel thickness was greater than 0.20 mm there was rarely any anthracnose and with peel thickness greater than 0.30 mm no anthracnose was observed. All pure Mexican race clones had peel thickness less than 0.30 mm, and all showed anthracnose (Table 1). Two cultivars, Alboyce and Tower #2, and two selections, WB-3-13-10 and WB-3-13-2 were found to have low or no anthracnose and had peel thickness of 0.22 mm or less. However, these four may have factors for resistance other than peel thickness. Anthracnose on selections rated low may be a more severe problem in years when weather conditions are more favorable for the disease development.

Taste varied among cultivars and selections. The Mexican race avocados that matured in late summer along with WV-3-3-11, 'Fuerte', and 'Reed' had a smooth buttery flavor. An undesirable anise flavor occurred in the fruit of 'Gainesville', 'Kizzia', WB-3-13-10, 'Bacon', and WA-2-2-21. However, 'Bacon' was grown commercially in California for years and its anise flavor did not disqualify the fruit for marketing. The desirable, nutty flavor was present in

Table 1. Avocado fruit physical attributes of cultivars and breeding lines grown at Weslaco, Texas - 1989.

Cultivar	Race ^Z	Maturity date	Peel color	Size (g)	Shape	Yield	Seed size (g)	Peel thickness (mm)	An-thracnose	Skin texture
Young #1	1	1 July-23 Aug	Black	110	Pyriform	High	22	0.11	Yes	Smooth
Young #2	1	1 July-30 Aug	Black	101	Pyriform	High	21	0.12	Yes	Smooth
WB3-13-7	2	1 Aug-30 Aug	Green	383	Cucumber	Low	56	0.14	Yes	Smooth
WA2-3-27	2	9 Aug-16 Aug	Green	387	Pyriform	Low	46	0.12	Yes	Smooth
Gainesville	1	9 Aug-6 Sept	Green	166	Pyriform	High	45	0.13	Yes	Rough
Kizzia	7	16 Aug-13 Sept	Black	344	Pyriform	High	94	0.12	Yes	Rough
WB3-14-14	2	1 Sept-7 Nov	Grn-pur	263	Pyriform	High	62	0.17	Yes	Smooth
WF3-3-11	2	13 Sept-5 Oct	Black	150	Pyriform	Medium	36	0.10	Yes	Smooth
Bernecker	5	15 Sept-14 Nov	Green	735	Ovate	High	93	0.51	None	Smooth
WB3-13-10	2	20 Sept-1 Nov	Black	282	Ovate	Medium	81	0.07	Low	Smooth
Tonnage	4	27 Sept-1 Nov	Green	553	Pyriform	High	93	0.71	None	Rough
Tower #2	5	27 Sept-12 Nov	Green	617	Oblate	Low	124	0.22	None	Smooth
Hass	7	Oct?	Black	282	Ovate	Medium	49	0.70	None	Rough
WB3-13-2	2	1 Oct-14 Oct	Green	738	Round	Low	152	0.13	Low	Smooth
Beta	4	1 Oct-7 Nov	Green	688	Ovate	Low	97	0.50	None	Smooth
Ettinger	6	1 Oct-1 Dec	Green	296	Pyriform	High	52	0.30	Low	Smooth
Bassage	5	4 Oct-25 Oct	Green	647	Ovate	Medium	101	0.51	None	Smooth
Alboyce	6	4 Oct-Dec?	Green	236	Cucumber	Low	27	0.17	None	Smooth
Lula	4	4 Oct-Jan	Green	352	Pyriform	High	96	1.07	None	Rough
Bacon	6	5 Oct-7 Nov	Green	365	Ovate	High	61	0.20	Yes	Smooth
Nesbitt	4	15 Oct-Jan?	Green	405	Round	High	81	1.15	None	Rough
Taylor	3	25 Oct-25 Nov	Green	272	Pyriform	Low	48	0.60	None	Smooth
Fuerte	6	1 Nov-Dec	Green	304	Pyriform	Low	42	0.30	Low	Smooth
Reed	3	Dec?	Green	260	Round	Medium	36	1.12	None	Smooth
WA2-2-21	6	Jan?	Green	269	Round	High	76	0.52	None	Smooth

^ZOrigin group: 1 = Mexican; 2 = seedling of Mexican pollinated by another race or hybrid; 3 = Guatemalan; 4 = Guatemalan × West Indian or reciprocal; 5 = West Indian; 6 = complex hybrid, primarily Mexican; 7 = complex hybrid, primarily Guatemalan.

the six selections already mentioned and rated as having potential for further testing. The highest taste quality was found in the fruit with sweet or sweet nutty flavor. Fruit having the most desirable sweet flavor to eat were from cultivars 'Tonnage', 'Lula' and selection WB-3-13-2. Selection WB-3-13-2 may be of particular interest for further testing in areas like the Lower Rio Grande Valley with a marginal climate because in addition to its good taste the fruit are free from anthracnose. Unfortunately its production at Weslaco, Texas in the first production year was not rated high.

The presence of vascular fiber that appears as woody strings in the flesh rendered fruit of several otherwise good cultivars unacceptable. The fruit from cultivars 'Gainesville' and 'Tower #2' were high in vascular fiber. Fruit from selection WB-3-14-14 was generally low in vascular fiber but fiber was present in a few fruit. The fruit of 'Ettinger' had no detectable vascular fiber.

Oil content averaged consistently above 14% for all potentially useful cultivars and selections. The cultivar with the highest oil content was 'Young #1' with 20.1%. Cultivars and selections with low oil content were 'Tower #2', 'Reed', and WA-2-2-21; however, the low oil content of WA-2-2-21 may be explained by the fact that the fruit had not reached maturity when oil analysis was performed.

The cultivar referred to as 'Kizzia' was a local selection in the Lower Rio Grande Valley which was grown and promoted by Mr. Buck Kizzia of Mercedes, Texas. The selection was

earlier maturing than 'Lula' and was promoted as more cold tolerant, although this was never substantiated. The 'Kizzia' cultivar had anise odor in the leaves and fruit, black skin when mature, and extremely high incidence of anthracnose on the fruit while still on the tree.

None of the avocado trees in this test were able to withstand the December 23, 1989 freeze which had 48 continuous hours below freezing during which 25 hours were below -2.8°C (27°F) with a minimum temperature of -8.3 (17°F). The freeze killed all but the 'Young #1' and 'Young #2' trees to within 15 cm (6 inches) from the soil surface. The two selections of 'Young' ('Young #1' and 'Young #2') had the main scaffold survive to between 3 and 4 feet above the ground. All of the potential cultivars have been observed to survive more cold than 'Lula' in tests in south Florida (personal communication from Dr. Robert Knight, Jr., USDA Subtropical Horticulture Research Station, Miami, FL.). The 'Ettinger', WB-3-14-14, and WA-2-3-27 have withstood temperatures of -3 to -4 C (mid-twenties F) with little or no damage to the foliage, and no loss in fruiting.

The positive findings in this study support further testing of several of the cultivars for more complete data on yield, fruit quality, and disease tolerance. If anthracnose tolerance is related to peel thickness as these data indicate, cold tolerant hybrids with anthracnose tolerance could be developed using

Table 2. Avocado physicochemical attributes of cultivars and breeding lines grown at Weslaco, Texas - 1989.

Cultivar	Edible flesh (%)	Flesh Color	Flavor	Vascular fiber	Oil (%)
Young #1	80	Yellow-green	Buttery	Low	20.1
Young #2	79	Yellow	Buttery	Low	18.7
WB3-13-7	85	Bright yellow	Buttery	Low	—
WA2-3-27	88	Yellow	Nutty	Low	—
Gainesville	73	Pale yellow	Anise	Many	13.7
Kizzia	73	Bright yellow	Anise	Low	—
WB3-14-14	77	Pale green	Nutty	Low	14.8
WF3-3-11	76	Cream	Buttery	Low	16.2
Bernecker	87	Bright yellow	Nutty	Low	13.5
WB3-13-10	71	Bright yellow	Anise	Low	18.2
Tonnage	83	Yellow	Sweet nutty	None	16.7
Tower #2	80	Bright yellow	Nutty	Many	9.9
Hass	83	Yellow-green	Nutty	Low	—
WB3-13-2	79	Yellow	Sweet nutty	Low	13.2
Beta	86	Bright yellow	Nutty	Low	—
Ettinger	82	Pale yellow	Nutty anise	None	17.1
Bassage	84	Bright yellow	Nutty	Low	11.0
Alboyce	88	Bright yellow	Nutty anise	None	12.1
Lula	73	Yellow-green	Sweet	None	14.1
Bacon	83	Cream	Anise	Low	—
Nesbitt	80	Bright yellow	Nutty	None	14.3
Taylor	82	Pale yellow	Nutty	Low	—
Fuerte	86	Yellow	Buttery	Low	18.9
Reed	86	Yellow	Buttery	None	8.6
WA2-2-21	72	Bright yellow	Anise	Low	9.7

Mexican race parentage. It is not unreasonable to develop an avocado that could produce fruit most years in south Texas with commercial market quality.

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