Intensities of Sensory Attributes in High- and Normal-Oleic Cultivars in the Uniform Peanut Performance Test

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ABSTRACT

In order to ascertain whether or not flavor differed between high- and normal-oleic peanuts (*Arachis hypogaea* L.), data from the quality assessment phase of the Uniform Peanut Performance Test (UPPT) were used to compare the mean of 27 high-oleic cultivars with 32 normal oleic cultivars and registered germplasm lines. No difference was detected for any sensory attribute intensity except stale/cardboardy. That difference was minor (0.16 vs. 0.28 flavor intensity units, P=0.0008) and favored high-oleics. Although there was no detectable difference between high- and normal oleic lines, there was variation among individual lines for oil content, roast color, and several sensory attributes (dark roasted, raw/beany, roasted peanutty, sweet aromatic, sweet, bitter, wood-hulls-skins, and "off flavors" stale/cardboard, fruity/fermented, and plastic/chemical). No variation at all was detected among lines for astringent, earthy, painty, metallic, or sour. The absence of large differences between the two major oleic acid types and the presence of variation among lines within types for some key attributes suggests that it is possible to identify high-oleic cultivars with superior flavor profiles.

Key Words: *Arachis hypogaea* L., flavor.

The high-oleic fatty acid seed oil trait in peanut (*Arachis hypogaea* L.) was discovered in the 1980s by researchers at the Univ. of Florida (Norden *et al*., 1987). Its inheritance was deduced (Moore and Knauft, 1989; Knauft *et al.*, 1993; López et al. 2001; Isleib et al. 2006d), and the trait was transferred by backcrossing into the runner-type Sunrunner cultivar (Norden *et al*., 1985). The first high-oleic cultivars were released in the 1990s (Gorbet and Knauft, 1997, 2000). Sunrunner was highly susceptible to the tomato spotted wilt (TSW) caused by *Tomato spotted wilt tospovirus*, and the new SunOleic cultivars were as well. The shortcomings of the first high-oleic cultivars and the need to pay a royalty to the Univ. of Florida due to their ownership of a US Utility Patent on the high-oleic trait made peanut growers reluctant to adopt high-oleic cultivars in spite of their clear advantages in terms of finished peanut products, particularly with respect to shelf life (Mozingo, 2004). Processors prefer high-oleic peanuts for some products, and most US peanut breeders have adopted elevated oleic acid level as an objective in their programs.

As more high-oleic peanut cultivars are released in the USA, processors and shellers have inquired whether or not flavor differences exist between high-oleic cultivars and normal ones. The Uniform Peanut Performance Test (UPPT) program provides a mechanism whereby advanced breeding lines of the runner or virginia market type from all three of the major US production regions are compared directly (Branch *et al*., 2014). Many UPPT entries are released as cultivars subsequent to their testing in the UPPT. In the years from 2001 through 2013, many high- and normal-oleic cultivars have been UPPT entries that were tested for flavor profile by the USDA-ARS Market Quality and Handling Research Unit (MQHRU) in Raleigh, NC. Even though not all cultivars were tested every year, there was sufficient overlap among entries between years, and check cultivars Florunner (Norden *et al.*, 1969) and NC 7 (Wynne *et al*., 1979) were included in most individual UPPT tests, allowing comparison among the larger group of cultivars.

There has been some review of the relative flavor profiles of high-and normal-oleic breeding lines (Isleib *et al*., 2006a) including a direct comparison of the near-isogenic cultivars, NC 7 and Brantley (Isleib et al., 2006c). Based on that limited data, there were not large differences in flavor between the two groups of breeding lines and cultivars. More data are available now. It was the objective of this work to use the UPPT flavor data to determine whether or not systematic differences exist between normal- and high-oleic peanut cultivars with respect to their flavor profiles.

Materials and Methods

The UPPT is a trial series that has continued for decades (Branch *et al.*, 2014) although collection of composition and sensory data did not begin until

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the 2001 trials. Each year, participants in the UPPT program grow a replicated field trial of breeding lines contributed by programs in southern US states including state-funded programs in Alabama, Florida, Georgia, North Carolina, Texas and Virginia and USDA-ARS programs in Georgia and Oklahoma. Test sites include three in the Virginia-Carolina production area (Suffolk, VA, Lewiston, NC, and Blackville, SC), three in the Southeastern area (Tifton, GA, Marianna, FL, and Headland, AL), and six in the Southwestern area (Brownfield, TX, La Mesa, TX, Seminole, TX, Pearsall, TX, Stephenville, TX, and Fort Cobb, OK). No more than three locations in the Southwest were used in a single year. After pods from the field reps were graded by the participants, a sample of pods was composited across reps and sent to the USDA-ARS National Peanut Research Laboratory at Dawson, GA, where an extensive array of physical properties were measured on pods and seeds. Samples of the predominating fractions of the shelled seeds (extra-large kernels or "ELK" for virginia-type breeding lines and jumbo or medium kernels for runner-type lines) were sent to the USDA-ARS MQHRU in Raleigh, NC.

Personnel in the USDA-ARS MQHRU roasted the peanuts to a Hunter L value of 49±1, ground the roasted peanuts to paste to eliminate kernel size and texture as sensory criteria, and presented the paste samples to a trained descriptive sensory panel that scored an array of sensory attributes or "flavor notes" using the lexicon developed by Johnsen *et al.* (2007). This lexicon has a continuous scale of intensity from 0 (no perception of the flavor) to 15 (most intense flavor). Paste color (brightness) was measured on the Hunter L scale on room-temperature paste using a Hunter Laboratories DP-9000 colorimeter equipped with a D25 L optical sensor (Hunter Associates Laboratories, Reston, VA).

Since the inception of the sensory evaluation of UPPT samples in 2001, sensory intensity scores for samples from the UPPT have been accumulated in a database maintained by the NCSU peanut breeding program. This database includes data on the fatty acid profiles of the various samples as well as the names assigned to breeding lines that were released as cultivars after inclusion in the program either as "official" entries, *i.e.*, ones grown in all UPPT tests that year, or as "local options," *i.e.*, entries grown at one or a few locations at the discretion of the individual participant. Local options often include cultivars commonly grown commercially in the area. If a cultivar was tested in the UPPT prior to inception of the flavor assessment program, it may appear in the database as a local option.

Thirty-two normal- and 27 high-oleic cultivars were identified on the basis of fatty acid concentrations measured as part of the UPPT quality assessment, their data extracted from the database, and the data subjected to an unbalanced analysis of variance using the general linear models procedure (PROC GLM) of SAS Ver. 9.3 (SAS Inst., Cary, NC). For the roasted peanut, sweet aromatic, sweet, and bitter sensory attributes, roast color linear and quadratic effects and the intensity of the fruity attribute were tested as covariates. The model selected for final use included any covariates found to be simultaneously significant ($P \leq 0.05$). Means adjusted to a common environmental effect were computed for the oleic acid groups and for individual lines within groups using the "least squares means" (LSMEAN) option. Means were separated using t-tests ($P \leq 0.05$).

Results and Discussion

There was no indication that normal- and high-oleic cultivars differed in any sensory trait except stale/cardboard (Tables 1, 2). The difference for that trait was very small (0.28 vs. −0.16 flavor intensity units (fiu), P=0.0008) and favored high-oleics. Although statistically different, the intensity scores for both groups were close to zero, *i.e.*, most often imperceptible, so it is questionable whether or not the statistically significant difference rises to the level of biological or economic significance. For UPPT samples, it is customary to assess flavor as quickly as possible after processing, and if paste samples must be stored, they are usually held at −15 C, a temperature at which oxidation and generation of the stale/cardboard flavor are negligible (Pattee *et al.*, 2002). Another experiment might be designed to assess flavor in samples of normal- and high-oleic cultivars maintained over longer periods of time at higher temperatures, but the effect of the high-oleic trait on retardation of the onset of rancid flavor is well known (Mozingo, 2004), and the apparent effect of the high-oleic trait on the other sensory attributes was not detected. Several of the negative sensory attributes such as raw beany or dark roast or so-called "off flavors" such as wood-hulls-skins, astringent, earthy, painty, metallic, and sour exhibited no genotypic variation whatever after accounting for the average effects of specific tests.

It is of interest that there was statistically significant variation among lines within oleic acid groups for the generally positive sensory attributes

Table 1. Registration articles or other references to cultivars.

Type/cultivar (expt'l designation)	Citation	**Type**/cultivar (expt'l designation)	Citation
Normal-oleic lines		High-oleic lines	
AgraTech AT 201	PVP Cert. 200000135 issued 11/15/02	ANorden (UF98511)	Gorbet, 2007a.
Bailey (N03081T)	Isleib *et al.*, 2011.	Brantley (N00090ol)	Isleib *et al.*, 2006c.
C-99R (UF94320)	Gorbet and Shokes, 2002.	Flavor Runner 458	PVP Cert. 9600242 issued 07/31/97.
Carver (UF97102)	Gorbet, 2006.	Florida Fancy (UF03618)	PVP Cert. 200800279 issued 09/14/12.
CHAMPS (VT 9506102-6)	Mozingo *et al.*, 2006	Florida-07 (UF04327)	Gorbet and Tillman, 2009.
Florunner (F435)	Norden *et al.*, 1969.	FloRun™ 107 (UF08301)	Tillman and Gorbet, 2015.
Georganic (C11-2-39)	Holbrook and Culbreath, 2008.	Georgia-02C (GA 982508)	Branch, 2003.
Georgia Green (GA T-2846)	Branch, 1996.	Georgia-04S (GA 982502)	Branch, 2005.
Georgia Greener (GA 011568)	Branch, 2007b.	Georgia-05E (GA 002506)	Branch, 2006.
Georgia-03L (GA 962533)	Branch, 2004.	Georgia-08V (GA 012535)	Branch, 2009.
Georgia-06G (GA 011557)	Branch, 2007a	Georgia-09B (GA 032902)	Branch, 2010.
Georgia-07W (GA 011514)	Branch and Brenneman, 2008.	Georgia-11J (GA 052533)	Branch, 2012.
Georgia-10T (GA 052529)	Branch and Culbreath, 2011.	Georgia-13M (GA 072716)	Branch, 2014.
Georgia-12Y (GA 072531)	Branch, 2013.	Hull (UF98326)	Gorbet, 2007b.
GP-NC WS 16 (SPT 06-06)	Tallury *et al.*, 2014.	McCloud (UF03326)	PVP Appl. 200800232 pending.
Gregory (N90009)	Isleib *et al.*, 1999.	OLin (Tx962120)	Simpson *et al.*, 2003b.
Jupiter (OK-B26)	No registration article published.	Red River Runner (ARSOK-R1)	Melouk *et al.*, 2013.
NC 9 (NC Ac 17404)	Wynne *et al.*, 1986.	Sullivan (N08075olCT)	PVP Appl. 201500287 pending.
NC-V 11 (NC Ac 18411)	Wynne *et al.*, 1991.	TAMnut OL06 (TX034342)	Baring *et al.*, 2006a.
NemaTAM (TP 301-1-8)	Simpson *et al.*, 2003c.	TAMrun OL01 (TX 977006)	Simpson *et al.*, 2003a.
NM Valencia A	Hsi and Finkner, 1972.	TAMrun OL02 (TX 977053)	Simpson *et al.*, 2006.
NM Valencia C	Hsi, 1980.	TAMrun OL07 (TX 033630)	Baring *et al.*, 2006b.
Okrun (OK-FH-14)	Banks *et al.*, 1989.	TAMrun OL12 (TxL 061816)	Burow *et al.*, 2014.
Perry (N93112C)	Isleib *et al.*, 2003.	TUFRunner™ 511 (UF11301)	PVP Cert. 201400249 issued 03/30/15.
Phillips (N98003)	Isleib *et al.*, 2006b.	TUFRunner™ 727 (UF10302)	PVP Cert. 201300199 issued 09/30/13.
Southwest Runner (OK-CF83-126)	Kirby *et al.*, 1998.	Wynne (N08081olJC)	PVP Appl. 201500288 pending.
Spanco	Kirby *et al.*, 1989.	York (UF04321)	Gorbet and Tillman, 2011.
Sugg (N03091T)	Isleib *et al.*, 2015.		
TAMrun 96 (TX 896100)	Smith *et al.*, 1998.		
Tifguard (C724-19-15)	Holbrook *et al.*, 2008.		
Titan (VT 9506083-3)	Balota *et al.*, 2011.		
Tifrunner (C34-24)	Holbrook and Culbreath, 2007.		

Table 2. Adjusted mean paste oil, color, and sensory attribute scores for high- and normal oleic cultivars tested in the Uniform Peanut Performance Test. Means adjusted to a common environmental effect.

	Extent of testing						Sensory attribute						
		Years			Oil	Roast	Dark	Raw	Roasted	Sweet			Wood-hulls-
Type/cultivar	Samples	No.	First	Last	concentration	color	roasted	beany	peanut	aromatic	Sweet	Bitter	skins
					% FW	Hunter L score	flavor intensity units (0 to 15)						
High oleic	**389**	**12**	**2001**	**2012**	**47.99ns**[a]	**49.66ns**	**2.93ns**	**2.11ns**	**4.67ns**	**2.98ns**	**2.41ns**	**2.60ns**	**3.08ns**
ANorden	23	2	2001	2002	47.23hij[b]	46.80f	3.13ef	2.08bc	5.15a	3.22a	2.52abc	2.35ab	3.12a-d
Brantley	10	2	2003	2007	48.05e-j	48.58c-f	3.04ef	2.04bc	4.37bcd	2.86bc	2.20bcd	2.76def	3.15cd
Flavor Runner 458	16	7	2002	2010	47.39hij	47.66def	3.12ef	1.93bc	4.84ab	3.20a	2.63a	2.56b-e	3.12cd
Florida Fancy	3	3	2004	2010	49.66a-d	51.30a-e	2.94c-f	2.23cd	4.38bcd	2.71bcd	2.11cd	3.01ef	3.14a-d
Florida-07	19	7	2004	2011	48.02f-j	50.09cde	2.93ef	2.10cd	4.77abc	3.05ab	2.49abc	2.45abc	3.06a-d
FloRun™ '107'	14	3	2008	2011	47.24hij	48.98c-f	2.99ef	2.01bc	4.81ab	3.11ab	2.62a	2.45abc	3.06a-d
Georgia-02C	13	5	2002	2009	47.47g-j	53.92a	2.58bcd	2.33cd	4.18cd	2.63cd	2.16cd	3.05f	3.00abc
Georgia-04S	14	1	2003	2003	47.49hij	51.70a-d	2.90def	2.13cd	4.62bc	2.87abc	2.22bcd	2.70c-f	3.14cd
Georgia-05E	9	1	2003	2003	49.36a-d	50.58cde	2.18a	2.92e	3.92d	2.41d	1.91d	2.98f	3.21d
Georgia-08V	9	1	2006	2006	48.19d-i	51.94abc	2.86c-f	2.14cd	4.47bcd	2.82bc	2.26bcd	2.75def	3.08a-d
Georgia-09B	13	2	2007	2011	48.32c-i	49.46c-f	2.97ef	2.07bc	4.85ab	3.10ab	2.48abc	2.52b-e	3.08a-d
Georgia-11J	9	1	2010	2010	48.65c-h	49.55c-f	3.06ef	2.01bc	4.46bcd	2.92abc	2.32bc	2.85ef	3.10a-d
Georgia-13M	9	1	2010	2010	48.82b-g	49.94cde	2.95ef	2.06bc	4.73bc	3.01ab	2.47abc	2.49a-d	3.11bcd
Hull	28	2	2001	2002	50.17ab	51.15b-e	3.00ef	2.11cd	4.84ab	3.03ab	2.40bc	2.64c-f	3.07bcd
McCloud	21	3	2003	2005	49.74abc	49.09c-f	3.01ef	2.03bc	4.83ab	3.13ab	2.52abc	2.46a-d	3.09a-d
OLin	5	5	2003	2010	46.45h-k	48.16c-f	2.97def	2.04bc	4.68abc	2.98ab	2.53abc	2.55a-e	3.01a-d
Red River Runner	17	6	2006	2011	47.96c-j	47.77def	3.05ef	1.99abc	4.71abc	3.06ab	2.38abc	2.52a-e	3.02a-d
Sullivan	2	2	2010	2011	46.93h-k	50.43b-e	2.98c-f	1.98abc	4.83ab	3.10ab	2.70a	2.46a-d	3.03a-d
TAMnut OL06	3	3	2005	2007	46.09h-k	51.98abc	2.84b-f	2.29cd	4.47bcd	2.89abc	2.50abc	2.61b-f	3.07a-d
TAMrun OL01	39	9	2001	2009	45.69jk	47.51ef	3.06ef	1.93bc	4.69bc	3.02ab	2.38bc	2.44abc	3.02a-d
TAMrun OL02	38	9	2001	2009	47.14hij	49.50c-f	2.94ef	2.14cd	4.89ab	3.13ab	2.51abc	2.53a-e	3.09a-d
TAMrun OL07	27	5	2005	2009	47.39hij	50.55cde	2.92ef	2.10cd	4.86ab	3.06ab	2.42abc	2.50a-d	3.03a-d
TAMrun OL12	1	1	2007	2007	48.69a-h	49.77a-f	2.71a-e	2.09a-d	4.52a-d	2.85abc	2.16bcd	2.51a-e	3.11a-d
TUFRunner™ 511	15	2	2011	2012	48.69c-h	47.84def	3.10ef	1.91abc	4.89ab	3.24a	2.65a	2.47a-d	3.10a-d
TUFRunner™ 727	13	3	2009	2011	49.22a-e	47.81def	3.01ef	2.01bc	4.75abc	3.12ab	2.61a	2.45abc	3.08a-d
Wynne	16	2	2010	2011	45.84ijk	49.88cde	3.02ef	2.01bc	4.72bc	3.02ab	2.52abc	2.63c-f	3.08bcd
York	3	3	2004	2006	49.76abc	48.87c-f	2.87c-f	2.26cd	4.76abc	3.02ab	2.53abc	2.56a-e	2.96abc
Normal oleic	**458**	**13**	**2001**	**2013**	**48.02ns**	**49.81ns**	**2.91ns**	**2.11ns**	**4.63ns**	**2.99ns**	**2.40ns**	**2.58ns**	**3.07ns**
Agratech AT201	4	1	2002	2002	47.68f-j	47.71def	3.29f	1.83ab	4.75abc	3.14ab	2.46abc	2.71c-f	3.18cd
Bailey	25	7	2005	2011	47.17hij	49.75c-f	2.95ef	2.04bc	4.54bc	2.94ab	2.36bc	2.61c-f	3.07bcd
C-99R	8	4	2002	2005	49.57a-d	52.02abc	2.55bc	2.34cd	4.60bc	3.05ab	2.49abc	2.47a-d	2.98abc
Carver	11	1	2001	2001	47.83g-j	48.99c-f	2.97ef	2.02bc	4.75abc	3.04ab	2.37bc	2.54b-e	3.13cd
CHAMPS	29	8	2002	2010	48.12g-j	49.58c-f	2.81c-f	2.15cd	4.47bcd	2.84bc	2.20cd	2.65c-f	3.02a-d
Florunner	115	13	2001	2013	48.12f-j	48.86c-f	3.04ef	1.98bc	4.56bc	2.94ab	2.35bc	2.60b-f	3.12bcd
Georganic	17	2	2002	2004	46.53h-k	46.94f	3.15ef	1.76a	4.45bcd	2.97ab	2.39bc	2.49a-d	2.95a
Georgia Green	44	11	2001	2011	49.28a-d	49.22c-f	2.86c-f	2.13cd	4.74abc	3.05ab	2.46abc	2.41ab	3.04a-d
Georgia Greener	11	2	2005	2010	50.36a	51.99abc	2.72b-e	2.36cd	4.77abc	3.08ab	2.38abc	2.42abc	3.00abc

Table 2. Continued

Type/cultivar	Extent of testing				Oil concentration	Roast color	Sensory attribute						
	Samples	Years					Dark roasted	Raw beany	Roasted peanut	Sweet aromatic	Sweet	Bitter	Wood-hulls-skins
		No.	First	Last									
Georgia-03L	23	2	2001	2002	48.31c-i	52.81ab	2.57bc	2.29cd	4.26bcd	2.89abc	2.30bcd	2.59c-f	2.96abc
Georgia-06G	11	3	2004	2013	49.54a-d	49.60c-f	2.93def	2.14cd	4.58bc	2.97ab	2.46abc	2.61b-f	3.09a-d
Georgia-07W	11	2	2005	2011	50.25ab	50.78b-e	2.74b-f	2.28cd	4.78abc	3.02ab	2.45abc	2.47a-d	3.10a-d
Georgia-10T	10	1	2008	2008	48.13d-j	48.43c-f	3.02ef	2.04bc	4.57bc	3.00ab	2.45abc	2.56b-e	3.10bcd
Georgia-12Y	10	1	2011	2011	47.45hij	49.50c-f	2.94ef	1.99bc	4.88ab	3.19a	2.67a	2.30a	2.98abc
Gregory	5	5	2003	2009	48.29c-i	51.70a-d	2.79b-f	2.12bcd	4.77abc	3.04ab	2.43abc	2.55a-e	3.01abc
Jupiter	1	1	2004	2004	47.69a-j	48.43c-f	3.29ef	1.89abc	4.80abc	2.80a-d	2.02cd	2.69a-f	3.05a-d
NC 9	1	1	2004	2004	48.75a-h	52.26abc	2.73a-f	2.32bcd	4.56abc	2.71bcd	2.26a-d	2.97def	3.14a-d
NC-V 11	7	7	2003	2010	48.46c-h	50.73cde	2.92ef	2.21cd	4.36bcd	2.76bcd	2.15cd	2.86ef	3.10a-d
NemaTAM	14	2	2001	2002	47.64hij	49.28c-f	2.97ef	2.10cd	4.85ab	3.08ab	2.42abc	2.53b-e	3.10bcd
NM Valencia A	1	1	2003	2003	46.63g-k	49.50c-f	2.81b-f	2.27bcd	4.59abc	3.26a	2.61ab	2.67a-f	3.09a-d
NM Valencia C	7	7	2003	2010	45.07k	46.93f	3.00ef	1.94abc	4.59bc	3.06ab	2.67a	2.38ab	2.96ab
Okrun	1	1	2009	2009	48.16a-j	51.51a-e	2.93b-f	2.14a-d	4.64abc	2.93abc	2.50abc	2.62a-f	3.12a-d
Perry	3	3	2004	2007	47.48g-j	49.05c-f	3.00ef	2.08bc	4.57bc	2.92abc	2.27bcd	2.65b-f	3.11a-d
Phillips	12	3	2002	2007	48.10e-j	48.57c-f	3.19ef	2.02bc	4.56bc	2.92abc	2.29bcd	2.78def	3.17cd
Southwest Runner	1	1	2009	2009	48.39a-i	51.78a-d	2.83b-f	2.14a-d	4.90ab	3.14ab	2.58abc	2.57a-f	3.12a-d
Spanco	2	2	2003	2005	48.63a-h	53.92ab	2.40ab	2.59d	4.69abc	3.08ab	2.43abc	2.41abc	3.05a-d
SPT 06-06	9	1	2010	2010	49.11a-f	48.20c-f	3.02ef	2.03bc	4.85ab	3.14a	2.57abc	2.57b-f	3.05a-d
Sugg	16	6	2005	2010	47.19hij	49.37c-f	3.00ef	2.04bc	4.54bc	2.91abc	2.37bc	2.59b-f	3.08bcd
TAMrun 96	14	5	2001	2006	45.85ijk	49.29c-f	2.86def	2.12cd	4.60bc	2.98ab	2.44abc	2.48a-d	3.05a-d
Tifguard	15	2	2006	2007	47.22hij	49.29c-f	2.94ef	2.07bc	4.70bc	3.04ab	2.46abc	2.51b-e	3.04a-d
Tifrunner	19	4	2002	2006	47.82g-j	50.91cde	2.74b-f	2.25cd	4.52bc	2.86bc	2.35bc	2.67c-f	3.10bcd
Titan	1	1	2009	2009	47.78a-j	46.89c-f	3.07c-f	1.99abc	4.30bcd	2.92abc	2.31a-d	2.78a-f	3.15a-d
Mean					**48.39**	**49.31**	**2.96**	**2.04**	**4.62**	**3.00**	**2.37**	**2.65**	**3.06**
CV (%)					**2.3**	**3.6**	**8.3**	**10.0**	**6.0**	**6.1**	**8.2**	**7.7**	**5.2**

[a]Abbreviations: ns, Denotes type or cultivar means for which the F-test of variation was not significant ($P \geq 0.05$); α and β, Type means followed by the same lower-case Greek letter are not significantly different by t-test ($P < 0.05$).

[b]Cultivar means followed by the same lower-case Roman letter are not significantly different by t-test ($P < 0.05$).

Table 3. Adjusted means for negative sensory attribute ("flavor note") scores for high- and normal oleic cultivars tested in the Uniform Peanut Performance Test. Means adjusted to a common environmental effect.

	Extent of testing				Sensory attribute							
		Years			Astring-	Stale/	Eruity/			Plastic/		
Type/cultivar	Samples	No.	First	Last	gent	card-boardy	fermented	Earthy	Painty	chemical	Metallic	Sour
					flavor intensity units (0 to 15)							
High oleic	**389**	**12**	**2001**	**2012**	**1.05ns**[a]	**0.16α**	**0.21ns**	**0.02ns**	**0.05ns**	**0.01ns**	**0.00ns**	**0.01ns**
ANorden	23	2	2001	2002	1.06ns	−0.02a[b]	0.31b-f	−0.05ns	0.04b	0.00ns	0.00ns	0.01ns
Brantley	10	2	2003	2007	1.07ns	0.38cd	0.09b-e	0.05ns	0.06b	0.01ns	0.00ns	0.01ns
Flavor Runner 458	16	7	2002	2010	1.05ns	0.18a-d	0.40ef	0.08ns	0.07b	0.01ns	0.00ns	0.02ns
Florida Fancy	3	3	2004	2010	1.05ns	0.34bcd	−0.11a-d	0.02ns	0.08ab	0.00ns	0.00ns	0.01ns
Florida-07	19	7	2004	2011	1.03ns	0.19a-d	0.29c-f	0.01ns	0.05b	0.00ns	0.00ns	0.01ns
FloRun™ 107	14	3	2008	2011	1.02ns	0.18a-d	0.33ef	0.03ns	0.04b	0.00ns	0.00ns	0.01ns
Georgia-02C	13	5	2002	2009	1.08ns	0.30a-d	0.21b-f	0.05ns	0.06ab	0.07ns	0.01ns	0.01ns
Georgia-04S	14	1	2003	2003	1.04ns	0.21a-d	0.08b-e	0.04ns	0.04b	0.01ns	0.00ns	0.01ns
Georgia-05E	9	1	2003	2003	1.07ns	0.20a-d	−0.09a-d	0.13ns	0.11b	0.01ns	0.00ns	0.01ns
Georgia-08V	9	1	2006	2006	1.00ns	0.21a-d	0.14b-e	0.02ns	0.11b	0.02ns	0.01ns	0.01ns
Georgia-09B	13	2	2007	2011	1.04ns	0.13abc	0.18b-f	0.01ns	0.05b	0.01ns	−0.01ns	0.01ns
Georgia-11J	9	1	2010	2010	1.08ns	0.20a-d	0.21b-f	0.01ns	0.44c	0.00ns	0.02ns	0.00ns
Georgia-13M	9	1	2010	2010	1.11ns	0.08ab	0.24b-f	−0.01ns	0.00ab	0.03ns	0.02ns	0.00ns
Hull	28	2	2001	2002	1.07ns	0.09ab	0.38ef	−0.01ns	0.14b	0.01ns	0.00ns	0.01ns
McCloud	21	3	2003	2005	1.01ns	0.10ab	0.15b-f	0.00ns	0.03ab	0.01ns	0.00ns	0.02ns
OLin	5	5	2003	2010	1.03ns	0.18a-d	0.08a-e	0.01ns	0.05ab	0.00ns	0.00ns	0.01ns
Red River Runner	17	6	2006	2011	1.03ns	0.18a-d	0.15b-f	0.01ns	0.03ab	0.01ns	0.00ns	0.01ns
Sullivan	2	2	2010	2011	1.00ns	−0.13a	0.40c-f	−0.01ns	−0.17a	0.00ns	0.01ns	−0.04ns
TAMnut OL06	3	3	2005	2007	1.07ns	0.23a-d	−0.05a-e	0.00ns	0.04ab	0.01ns	0.01ns	0.01ns
TAMrun OL01	39	9	2001	2009	1.03ns	0.18a-d	0.33ef	0.05ns	0.02ab	0.01ns	0.00ns	0.00ns
TAMrun OL02	38	9	2001	2009	1.09ns	0.02ab	0.31c-f	0.03ns	0.05ab	0.02ns	0.00ns	0.02ns
TAMrun OL07	27	5	2005	2009	1.03ns	0.16abc	0.29c-f	0.01ns	0.04b	0.01ns	0.01ns	0.02ns
TAMrun OL12	1	1	2007	2007	1.04ns	0.27a-d	−0.07a-e	0.01ns	0.03ab	0.01ns	0.00ns	0.01ns
TUFRunner™ 511	15	2	2011	2012	1.03ns	0.03ab	0.32c-f	0.01ns	0.02ab	0.01ns	0.00ns	0.00ns
TUFRunner™ 727	13	3	2009	2011	1.03ns	0.19a-d	0.35ef	0.00ns	0.01ab	0.00ns	0.00ns	0.01ns
Wynne	16	2	2010	2011	1.04ns	0.06ab	0.20b-f	0.01ns	−0.02ab	0.01ns	0.02ns	0.01ns
York	3	3	2004	2006	1.08ns	0.16abc	0.62ef	0.02ns	0.03ab	0.01ns	0.01ns	0.01ns
Normal oleic	**458**	**13**	**2001**	**2013**	**1.03ns**	**0.28β**	**0.19ns**	**0.04ns**	**0.05ns**	**0.01ns**	**0.01ns**	**0.01ns**
Agratech AT201	4	1	2002	2002	1.06ns	0.13abc	0.14b-e	0.03ns	0.01ab	0.01ns	−0.02ns	0.01ns
Bailey	25	7	2005	2011	1.03ns	0.33cd	0.17b-f	0.03ns	0.06b	0.01ns	0.01ns	0.00ns
C-99R	8	4	2002	2005	1.03ns	0.26a-d	0.15b-f	0.02ns	0.03ab	0.01ns	0.02ns	0.01ns
Carver	11	1	2001	2001	1.05ns	0.24a-d	0.29b-f	–	−0.04ab	–	–	–
CHAMPS	29	8	2002	2010	1.03ns	0.36cd	0.07b-e	0.04ns	0.06b	0.01ns	0.01ns	0.00ns
Florunner	115	13	2001	2013	1.05ns	0.48cd	0.25b-f	0.03ns	0.06b	0.01ns	0.03ns	0.00ns
Georganic	17	2	2002	2004	1.00ns	0.17abc	0.32ef	0.07ns	0.08b	0.01ns	0.00ns	0.02ns
Georgia Green	44	11	2001	2011	1.02ns	0.73d	0.18b-f	0.05ns	0.02ab	0.01ns	0.01ns	0.01ns
Georgia Greener	11	2	2005	2010	1.02ns	0.20a-d	0.17b-f	0.14ns	0.08b	0.01ns	0.00ns	0.01ns

Table 2. Continued

Type/cultivar	Extent of testing				Sensory attribute							
		Years			Astring-gent	Stale/ card-boardy	Eruity/ fermented	Earthy	Painty	Plastic/ chemical	Metallic	Sour
	Samples	No.	First	Last								
Georgia-03L	23	2	2001	2002	1.07ns	0.23a-d	0.31c-f	0.09ns	0.12b	0.00ns	0.01ns	0.03ns
Georgia-06G	11	3	2004	2013	0.99ns	0.39cd	0.16b-f	0.10ns	0.09b	0.01ns	0.01ns	0.01ns
Georgia-07W	11	2	2005	2011	1.04ns	0.46cd	0.16b-f	0.05ns	0.05ab	0.01ns	0.00ns	0.01ns
Georgia-10T	10	1	2008	2008	1.03ns	0.28bcd	0.56ef	0.03ns	0.06b	0.01ns	0.01ns	0.05ns
Georgia-12Y	10	1	2011	2011	1.02ns	0.10abc	0.18b-f	−0.02ns	−0.03ab	0.01ns	−0.01ns	0.00ns
Gregory	5	5	2003	2009	1.02ns	0.23a-d	0.14b-e	0.03ns	0.08b	0.01ns	0.01ns	0.00ns
Jupiter	1	1	2004	2004	1.01ns	0.11abc	−0.39abc	−0.06ns	0.18bc	0.01ns	0.01ns	0.02ns
NC 9	1	1	2004	2004	1.01ns	0.34a-d	0.15a-f	0.02ns	0.04ab	0.01ns	0.01ns	0.01ns
NC-V 11	7	7	2003	2010	1.03ns	0.23a-d	0.09b-e	0.05ns	0.04ab	0.01ns	0.00ns	0.00ns
NemaTAM	14	2	2001	2002	1.08ns	0.19a-d	0.35def	0.06ns	0.06b	0.00ns	0.00ns	0.01ns
NM Valencia A	1	1	2003	2003	1.02ns	0.10abc	−0.41ab	0.05ns	0.06ab	0.01ns	0.00ns	0.12ns
NM Valencia C	7	7	2003	2010	1.05ns	0.27bcd	0.18b-f	−0.02ns	0.04ab	0.01ns	0.00ns	0.01ns
Okrun	1	1	2009	2009	1.02ns	0.27a-d	1.11f	0.03ns	0.05ab	0.01ns	0.01ns	0.01ns
Perry	3	3	2004	2007	1.03ns	0.20a-d	0.22b-f	0.03ns	0.05ab	0.00ns	0.01ns	0.01ns
Phillips	12	3	2002	2007	1.09ns	0.54cd	0.13b-e	0.04ns	0.06b	0.02ns	0.00ns	0.01ns
Southwest Runner	1	1	2009	2009	1.05ns	0.17a-d	0.17a-f	0.03ns	0.05ab	0.01ns	0.01ns	0.01ns
Spanco	2	2	2003	2005	1.02ns	0.17abc	−0.44a	0.12ns	0.04ab	0.01ns	0.00ns	0.01ns
SPT 06-06	9	1	2010	2010	1.05ns	−0.07a	0.38ef	0.00ns	0.04ab	0.00ns	0.02ns	0.00ns
Sugg	16	6	2005	2010	1.02ns	0.41cd	0.09b-e	0.02ns	0.10b	0.02ns	0.02ns	0.00ns
TAMrun 96	14	5	2001	2006	1.01ns	0.26bcd	0.59ef	0.15ns	0.05b	0.01ns	0.00ns	0.01ns
Tifguard	15	2	2006	2007	1.03ns	0.30bcd	0.18b-f	0.03ns	0.04b	0.01ns	0.01ns	0.01ns
Tifrunner	19	4	2002	2006	1.05ns	0.51cd	0.19b-f	0.04ns	0.05b	0.01ns	0.03ns	0.01ns
Titan	1	1	2009	2009	0.99ns	0.32a-d	0.18a-f	0.03ns	0.06ab	0.01ns	0.01ns	−0.09ns
Mean					**1.05**	**0.24**	**0.21**	**0.03**	**0.05**	**0.00**	**0.01**	**0.01**
CV (%)					**13.2**	**101.8**	**147.5**	**296.5**	**274.0**	**493.9**	**496.3**	**557.7**

[a]Abbreviations: ns, Denotes type or cultivar means for which the F-test of variation was not significant ($P \geq 0.05$); α and β, Type means followed by the same lower-case Greek letter are not significantly different by t-test ($P < 0.05$).

[b]Cultivar means followed by the same lower-case Roman letter are not significantly different by t-test ($P < 0.05$).

roasted peanutty, sweet aromatic, and sweet and for the generally negative ones bitter, fruity/fermented, stale/cardboard, and plastic/chemical. Roasted peanutty intensities ranged from 3.92 to 5.15 fiu for high-oleics and 4.26 to 4.89 fiu for normal-oleics. Sweet aromatic intensities ranged from 2.41 to 3.24 fiu for high-oleics and 2.71 to 3.24 fiu for normal-oleics. Sweet intensities ranged from 1.91 to 2.70 fiu for high-oleics and 2.02 to 2.70 fiu for normal-oleics. Bitter intensities ranged from 2.35 to 3.05 fiu for high-oleics and 2.30 to 3.05 fiu for normal-oleics. Wood/hulls/skins intensities ranged from 2.96 to 3.21 fiu for high-oleics and 2.95 to 3.21 fiu for normal-oleics. Stale/cardboardy intensities ranged from 0.13 to 0.38 fiu for high-oleics and −0.07 to 0.38 fiu for normal-oleics. Fruity/fermented intensities ranged from 0.11 to 0.62 fiu for high-oleics and −0.44 to 0.62 fiu for normal-oleics. Plastic/chemical intensities ranged from 0.17 to 0.44 fiu for high-oleics and −0.04 to 0.44 fiu for normal-oleics.

In each case, if it was a positive sensory attribute, the upper limit for the high-oleic cultivars was greater than or statistically equivalent to that for the normal-oleics; if it was a negative attribute, then the lower limit for the high-oleics was less than or statistically equivalent to the limit for normal-oleics. This suggests that it is possible to identify high-oleic cultivars with superior flavor profiles, at least as good as profiles of normal-oleic cultivars.

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