Genotypic Variation in Roasted Peanut Flavor Quality Across 60 Years of Breeding[1]

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ABSTRACT

In developing new peanut (*Arachis hypogaea* L.) breeding lines and cultivars, the breeder's primary focus is upon those heritable characteristics with direct, measurable effects. Flavor quality characteristics are heritable but do not have a directly measurable economic value, so they are often overlooked. Failure to monitor and evaluate flavor quality may lead to serious defects in new breeding lines and cultivars. Flavor quality data on lines developed since 1930 were examined to identify trends in flavor quality of the cultivars and breeding populations in the virginia, runner, and fastigiate market types. Virginia-type cultivars have trended toward poorer roasted peanut flavor (reduced intensity of the roasted peanut and sweet attributes and increased intensity of the bitter attribute). Use of the commercially successful cultivars Florigiant and NC 7 in the ancestry of new breeding lines appears to have reduced the flavor quality. Runner-type cultivars increased slightly in average sweetness over time, but there has been an increase in the variance of roasted peanut intensity in the breeding population since 1980. Introgression of disease-resistant germplasm into the breeding populations appears to have had a detrimental effect on the flavor of lines in the runner and virginia market types. Use of Florunner, a multiline cultivar with a superior flavor profile, as a parent of breeding lines has contributed to generally superior flavor in the runner market type. The gains possibly could have been greater had one of Florunner's better-tasting components been used consistently in crossing programs. The limited sample of fastigiate lines and cultivars in this study showed consistent improvement in the intensities of roasted peanut and bitter attributes. Spanish-type cultivars showed improvement in the sweet attribute.

Key Words: *Arachis hypogaea* L., bitter, germplasm, improvement, market type, sweet.

In developing new breeding lines and cultivars, the primary focus is upon those heritable characteristics that impact agronomic value and pest resistance because of the direct, measureable effect. Those characteristics which are heritable but do not have a directly measureable economic value can sometimes be overlooked or forgotten as new breeding lines and cultivars are developed because they do not immediately affect profit margin. One such set of characteristics is flavor quality. However, failure to monitor and evaluate these characteristics and to understand the potential of the proposed parents to transfer them to their progeny can lead to serious quality defects in new breeding lines and cultivars (Isleib *et al.*, 1995).

Through the research of Pattee and coworkers, an understanding of the genotypic and environmental influences on roasted peanut (*Arachis hypogaea* L.) flavor quality has been provided (Pattee *et al.*, 1994, 1997, 1998). It also was shown that there are highly significant correlations among least square means for the attributes, particularly bitter with sweet and roasted peanut with sweet and bitter (Pattee *et al.*, 1997, 1998). Additionally, they have shown that certain roasted peanut quality sensory attributes are heritable traits (Pattee and Giesbrecht, 1990; Pattee *et al.*, 1993, 1994, 1995, 1998; Isleib *et al.*, 1995). Thus, through these efforts the long-standing objective of the peanut industry to enhance the intensity of roasted peanut flavor in peanut products is being addressed.

The genotypic-flavor quality data set compiled from the above cited work provides a unique opportunity to examine the trends in flavor quality of selected ancestral lines and the most common peanut cultivars in the runner, spanish, and virginia market types spanning 60 yr of peanut breeding history. Such information will be useful in directing the selection of potential parents for future cultivar development while still maintaining or enhancing the flavor quality of these new cultivars.

Materials and Methods

Genotype Resources. From 1986 to 1998, 1406 peanut samples were obtained from the Southeast, Southwest, and Virginia-Carolina peanut production regions. Represented within the samples were 143 genotypes, including selected ancestral lines and the most common peanut cultivars in the runner, spanish, and virginia market types (Table 1). Genotypes included in this paper were those whose mean values comprised at least three observations and two locations, thus providing reasonable estimates of the experimental

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Table 1. Cultivars and lines evaluated for selected sensory attributes.

Year	Cultivar or line	State	Year	Cultivar or line	State	Year	Cultivar or line	State
Large-seeded virginia			**Large-seeded virginia (cont'd)**			**Runner (cont'd)**		
1930	Dixie Giant*	FL	1990	NC Ac 18487	NC	1969	Florunner Comp. 4*	FL
1930	Holland Virginia Jumbo*	VA	1990	N90002	NC	1976	NC 3033	NC
1930	White's Runner*	NC	1990	UF82107	FL	1982	GK-7*	GA
1944	NC 4*	NC	1990	UF87118	FL	1982	Sunbelt Runner*	GA
1947	Jenkins Jumbo	GA	1991	AT VC-1*	GA	1982	Sunrunner*	FL
1952	NC 2*	NC	1991	N90016	NC	1984	Southern Runner*	FL
1954	GA 119-20*	GA	1991	N90017	NC	1986	Langley*	TX
1959	F393-7-1-b4-B	FL	1991	VA861101	VA	1986	Okrun*	OK
1961	Florigiant*	FL	1991	VA861120	VA	1988	Tamrun 88*	TX
1970	NC Ac 17921	NC	1992	N91003E	NC	1988	UGA-3-5	GA
1970	NC Ac 18016	NC	1992	N91045	NC	1988	UGA-3-6	GA
1972	Altika (UF714021)*	FL	1992	VA-C 92R*	VA	1988	UGA-3-7	GA
1976	NC 6*	NC	1993	VA 93B*	VA	1988	UGA-3-8	GA
1977	Early Bunch*	FL	1994	N90010E	NC	1988	UGA-3-9	GA
1977	Early Bunch Comp. 1*	FL	1994	N91047	NC	1988	UGA-3-10	GA
1977	Early Bunch Comp. 2*	FL	1994	N91048	NC	1988	UGA-3-11	GA
1977	Early Bunch Comp. 3*	FL	1996	NC 12C*	NC	1990	Georgia Runner*	GA
1977	Early Bunch Comp. 4*	FL	1997	Gregory*	NC	1990	MARC I*	FL
1977	Early Bunch Comp. 5*	FL	1997	N92056C	NC	1991	AT 127*	GA
1978	NC 7*	NC	1998	X90037	NC	1991	UF86107	FL
1982	NC 8C*	NC	1998	X90042	NC	1991	UF90106	FL
1985	NC 9*	NC	1998	X90053	NC	1991	UGA-4-3	GA
1988	NC 10C*	NC	1998	86X45B-10-1-2-2-	FL	1992	TP107-11	TX
1988	NC Ac 18423	NC	1998	86X45B-8-1-1-b3-	FL	1992	UF81206-2	FL
1988	NC Ac 18424	NC	2000	Perry (N93112C)*	NC	1992	UGA-4-1	GA
1988	NC Ac 18426	NC				1992	UGA-4-2	GA
1988	NC Ac 18431	NC	**Runner**			1992	UGA-5	GA
1988	NC Ac 18449	NC	1930	Basse	-	1992	UGA-6	GA
1988	NC Ac 18450	NC	1931	PI 109839	-	1993	Andru 93*	FL
1988	NC Ac 18451	NC	1943	Dixie Runner*	FL	1993	F1315	FL
1988	NC Ac 18452	NC	1943	GA 207-2	GA	1993	F1316	FL
1988	NC Ac 18454	NC	1943	GA 207-3-4	GA	1994	UGA-7	GA
1988	NC Ac 18455	NC	1947	SE Runner 56-15*	GA	1994	UGA-8	GA
1988	NC Ac 18456	NC	1952	Early Runner*	FL	1994	UGA-9	GA
1988	NC Ac 18457	NC	1952	Early Runner Comp. 1*	FL	1995	SunOleic 95R (F1250)*	FL
1988	NC Ac 18459	NC	1952	Early Runner Comp. 2*	FL	1997	SunOleic 97R (F1334)*	FL
1988	NC Ac 18460	NC	1952	Early Runner Comp. 3*	FL	1998	Fla MDR 98 (UF91108)*	FL
1988	NC Ac 18462	NC	1952	Early Runner Comp. 4*	FL			
1988	NC Ac 18463	NC	1952	Early Runner Comp. 5*	FL	**Fastigiate**		
1988	NC Ac 18464	NC	1957	Bradford Runner*	FL	1930	Small White Spanish	FL
1988	NC Ac 18469	NC	1961	Florispan Comp. 1*	FL	1930	Spanette (Spanish 18-38-42)*	GA
1988	N88003	NC	1961	Florispan Comp. 2*	FL	1933	Improved Spanish 2B	GA
1988	VA830215-1	VA	1961	Florispan Comp. 3*	FL	1937	Pearl	FL
1988	VA830416-1	VA	1961	Florispan Comp. 4*	FL	1961	Starr*	TX
1988	VA830516-1	VA	1961	Florispan Comp. 5*	FL	1968	PI 337396	-
1988	VP8407	VA	1969	Florunner*	FL	1979	New Mexico Valencia C*	NM
1988	VP8417	VA	1969	Florunner Comp. 1*	FL	1980	Pronto*	OK
1988	VP8420	VA	1969	Florunner Comp. 2*	FL	1981	Spanco*	OK
1989	NC-V 11*	NC	1969	Florunner Comp. 3*	FL	1990	Tamspan 90*	TX

* Denotes cultivars for which certified seed production records are extant.

error in the mean values (Pattee *et al.*, 1994). Fifty-six year-by-location combinations were represented in the data. All samples were obtained from plants grown and harvested under standard recommended procedures for the specific location. The year of release or development associated with a particular genotype was assigned using the following criteria. Ancestral lines with no known pedigree were assigned 1930. Improved cultivars and registered germplasm lines were assigned the year of release reported in registration articles. Unreleased breeding lines were assigned the last year in which they were evaluated for flavor except where information was available from the developer to permit a more definitive designation.

Sample Handling. Each year a 1000-g sample of the sound mature kernel (SMK) fraction from each replicate of each location-entry was shipped to Raleigh, NC in February following harvest and placed in controlled storage at 5 C and 60% relative humidity (RH) until roasted.

Sample Roasting and Preparation. The peanut samples were roasted between May and June using a Blue M "Power-O-Matic 60" laboratory oven, ground into a paste, and stored in glass jars at -20 C until evaluated. The roasting, grinding, and color measurement protocols were as described by Pattee and Giesbrecht (1990).

Sensory Evaluation. A long-standing, six- to eight-member trained roasted peanut profile panel in the Food Science Dept., North Carolina State Univ., Raleigh, NC, evaluated all peanut-paste samples using a 14-point flavor intensity unit (fiu) scale. Panel orientation and reference control were as described by Pattee and Giesbrecht (1990) and Pattee *et al.* (1993). Two sessions were conducted each week on nonconsecutive days. Panelists evaluated four samples per session. Sensory evaluation commenced in June or July of each year and continued until all samples were evaluated. The averages of individual panelists' scores on sensory attributes were used in all analyses.

Statistical Analysis. PROC MIXED in SAS (1997) was used for analysis of the unbalanced data set to estimate the sensory attribute least square means for genotypes. Covariates fruity and roast color were used, as needed, based upon the findings of Pattee *et al.* (1991, 1997) and Pattee and Giesbrecht (1994). The fixed effects were genotype, region, genotype-by-region. Each genotype effect was partitioned to reflect the effects of market type and genotype within market types. Classification of lines into market types was based upon branching pattern, pod type, and seed size. Because there was only one valencia market type in this study, it was pooled with the spanish market type into a single group hereafter called 'fastigiate' market type. Trends in flavor attributes were detected by regression analysis of the least square means. Two regressions were performed for each market type—one using data from all lines to indicate the trend in the overall breeding population and a second using data only from cultivars to indicate the trend in peanuts available to processors. Cultivars were determined by examination of seed production records published by the Amer. Organization of Seed Certifying Agencies (AOSCA). Data on components of multiline cultivars released by the Univ. of Florida were included in the regression for cultivars.

Results and Discussion

There are four different U.S. peanut market types—virginia, runner, spanish, and valencia. The genetic background of the last two is entirely from the subsp. *fastigiata* Waldron, the spanish lines from botanical var. *vulgaris* Harz, and the valencia lines from botanical var. *fastigiata*. This commonality, along with the low sample number, was the rationale for pooling the eight spanish lines with the two valencia in this study and designating them as 'fastigiate'. The virginia and runner market types have the alternate branching pattern typical of subsp. *hypogaea* and pod characteristics typical of botanical var. *hypogaea*. Their genetic base is predominantly the *hypogaea* botanical variety, but all current cultivars and breeding lines have at least some ancestry from subsp. *fastigiata*.

Flavor changes of interest to the peanut industry and to breeders include linear trends over time and changes in the amount of variation in flavor among cultivars and lines of a particular period. Trends over time should not be interpreted as genetic gain, which refers to progress made in a closed breeding population. Because the different market types have different end uses, the results are presented separately for market types.

Large-Seeded Virginia Market Type. Although there was no significant trend of the roasted peanut attribute across years for all lines in the virginia market type, sweetness decreased and bitterness increased (Fig. 1a,b,c). Considering cultivars only, the trends are accentuated, and the trend of decreasing roasted peanut attribute over time is statistically significant, accounting for 26% of the observed variation.

It is notable that the cluster of ancestral lines used to initiate the virginia breeding programs in Florida and North Carolina (Dixie Giant, Holland Virginia Jumbo, NC 4, and White's Runner) had superior levels of roasted peanut and sweet attributes. Based on these values, one might predict the average values of subsequent virginia-type cultivars and lines to be higher than are observed. It appears that the introgression of Jenkins Jumbo ancestry into the overall virginia population, primarily through its commercially successful descendants Florigiant and NC 7, contributed to a general weakening of the roasted peanut scores of later lines. The deleterious ancestral effect of Jenkins Jumbo on the roasted peanut attribute has been documented (Isleib *et al.*, 1995) and the calculation of its breeding value for the roasted peanut attribute further confirms these observations (Pattee *et al.*, 2001).

Also notable is the generally inferior flavor profile associated with cultivars resistant to Cylindrocladium black rot (CBR, caused by *Cylindrocladium parasiticum* Crous, Wingfield & Alfenas). One cannot conclude that CBR resistance causes decreases in roasted peanut and sweet attributes or increases in the bitter attribute, but there appears to be an association. The four CBR-resistant cultivars released by NCSU derive their resistance from different sources—NC 8C and NC 10C from NC Ac 03139; NC 12C from NC 2; and Perry from NC 2 and NC 3033. Although all four are descended from Florigiant, NC 12C and Perry also are descended from NC 7. The flavor differential between the average CBR-resistant line and the average susceptible line was positive in the 1970s, negative in the 1980s, and neutral in the 1990s (Table 2). The focus of the North Carolina program on CBR resistance has been at cross purposes with the improvement of flavor quality in the virginia market type. However, with monitoring of flavor, it has been possible to make small incremental improvements in roasted peanut and bitter attributes above NC 10C with the release of NC 12C and Perry.

In the virginia market type, it is clear that the commercial success of cultivars has not been a function of their flavor profiles. NC 2 had a superior profile and was popular in the limited seed market of its time, but Florigiant was the first cultivar documented to predomi-

Table 2. Summary statistics on flavor attributes of cultivars and lines in the large-seeded virginia, runner, and fastigiate market types.

Group of lines	No. of lines	Roasted peanut		Sweet		Bitter	
		Mean	SD	Mean	SD	Mean	SD
		flavor intensity units					
Virginia market type	74	4.02	0.25	2.84	0.30	3.66	0.31
Lines prior to 1950	5	4.19	0.25	3.25	0.08	3.39	0.31
Lines from the 1950s	3	4.14	0.21	3.04	0.09	3.51	0.27
Lines from the 1960s (Florigiant)	1	3.84	---	2.61	---	3.81	---
Lines from the 1970s	11	4.00	0.16	2.82	0.33	3.69	0.36
CBR-resistant lines[a]	1	4.33	---	3.50	---	2.83	---
Others	10	4.03	0.13	2.87	0.30	3.66	0.36
Early Bunch	1	3.92	---	2.82	---	3.82	---
Early Bunch components	5	4.05	0.13	2.69	0.07	3.85	0.13
Lines from the 1980s	29	4.06	0.22	2.82	0.28	3.62	0.26
CBR-resistant lines[a]	3	3.79	0.07	2.56	0.08	3.90	0.20
Others	26	4.09	0.21	2.85	0.28	3.59	0.25
Lines from the 1990s	25	3.96	0.30	2.78	0.29	3.76	0.34
CBR-resistant lines[a]	4	4.04	0.28	2.65	0.25	3.86	0.13
Others	21	3.94	0.31	2.80	0.29	3.75	0.36
Runner market type	59	4.24	0.28	3.01	0.26	3.41	0.35
Lines prior to 1950	6	4.14	0.17	2.82	0.21	3.72	0.20
Lines from the 1950s	7	4.24	0.19	2.87	0.27	3.40	0.24
Early Runner	1	4.18	---	2.70	---	3.32	---
Early Runner components	5	4.26	0.21	2.92	0.31	3.33	0.24
Lines from the 1960s	10	4.33	0.14	3.19	0.30	3.14	0.35
Florispan components	5	4.20	0.16	2.93	0.37	3.24	0.45
Florunner	1	4.39	---	3.29	---	3.07	---
Florunner components	4	4.47	0.15	3.48	0.22	3.03	0.31
Lines from the 1970s	1	3.80	---	2.66	---	3.86	---
Lines from the 1980s	14	4.22	0.20	3.03	0.29	3.31	0.23
Lines from the 1990s	21	4.26	0.25	3.04	0.20	3.49	0.29
Andru, MARC I, high oleics[b]	6	4.60	0.10	3.15	0.17	3.35	0.19
Leaf spot-resistant lines[c]	2	4.15	0.23	3.02	0.01	3.99	0.13
Other 1990s lines	13	4.12	0.30	2.99	0.23	3.48	0.31
Lines earlier than 1980	24	4.24	0.21	2.98	0.30	3.39	0.33
Lines from the 1980s and 1990s	35	4.24	0.32	3.03	0.23	3.42	0.37
Fastigiate market type	10	4.16	0.24	3.23	0.51	3.31	0.62
Ancestral lines[d]	5	4.18	0.34	3.02	0.55	3.68	0.63
Spanish cultivars[e]	5	4.09	0.17	3.16	0.35	3.24	0.50

[a]CBR-resistant lines: 1970s---NC Ac 18016; 1980s---NC 8C, NC 10C, NC Ac 18469; 1990s---N91048, NC 12C, N92056C, Perry.
[b]High oleic lines: F1315, F1316, SunOleic 95R, SunOleic 97R.
[c]Leaf spot-resistant lines: UF 81206-2, Fla MDR 98.
[d]Fastigiate ancestral lines: Improved Spanish 2B, Pearl, PI 337396, Small White Spanish, Spanish 18-38-42.
[e]Spanish cultivars: Pronto, Spanco, Spanish 18-38-42, Starr, Tamspan 90.

nate across the entire Virginia-Carolina peanut production region (Isleib and Wynne, 1992). Florigiant combined excellent pod characteristics desired by shellers with high yield potential desired by growers, but its flavor attributes were inferior. Because of its commercial success, Florigiant was widely used as a parent in large-seeded, virginia-type breeding programs, perhaps with a deleterious effect on subsequent releases descended from it. NC 7 was the next cultivar to dominate the virginia market type. The primary reason for NC 7's release was its high content of jumbo pods and extra large kernels. Again, flavor was not a primary consideration in its release. Altika and AT VC-1 are examples of virginia-type cultivars with good flavor profiles that failed to dominate the market type.

Runner Market Type. The only significant trend detected in the runner market type was an increase in sweetness in cultivars ($P < 0.05$) (Fig. 2a,b,c). There was a change in variance over time in roasted peanut attribute. Lines developed or released during or after 1980

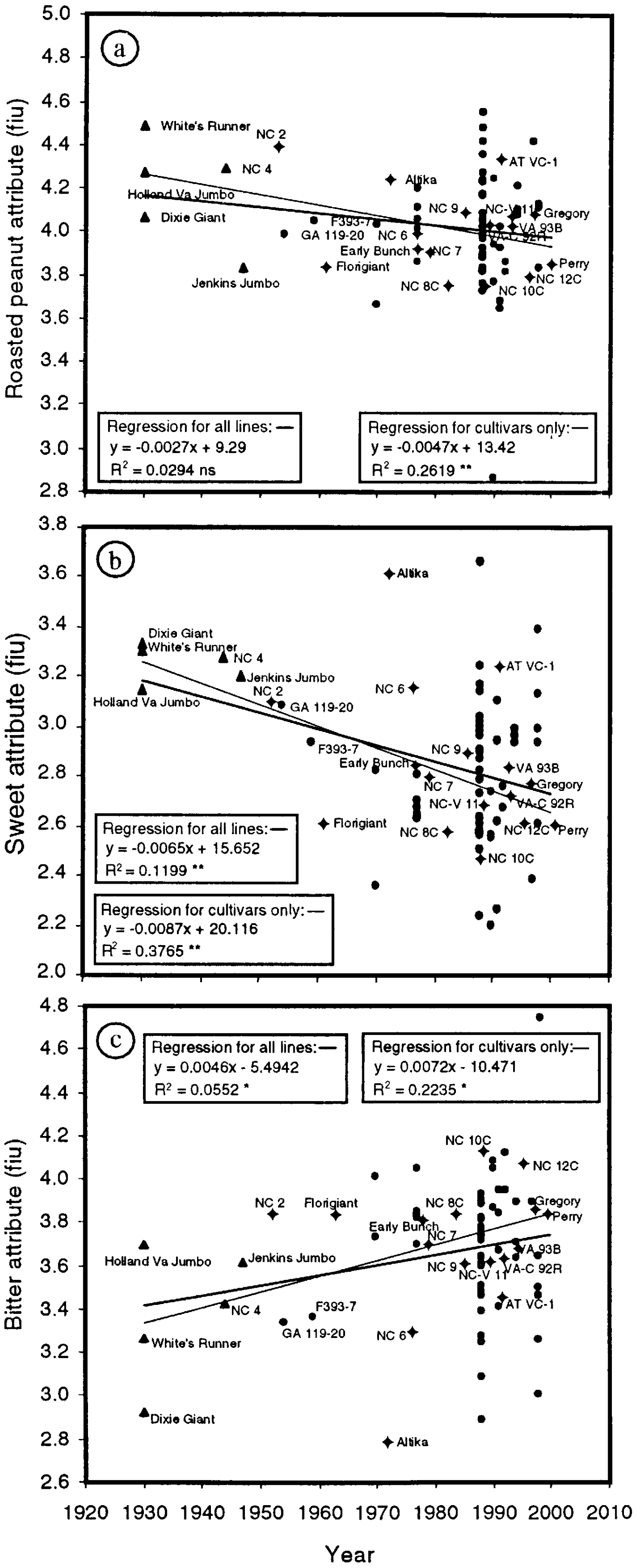

Fig. 1. Least square means for roasted peanut (a), sweet (b), and bitter (c) sensory attributes versus year of release or development for 74 cultivars (✦), ancestral lines (▲), and breeding lines (●) of the large-seeded virginia market type.

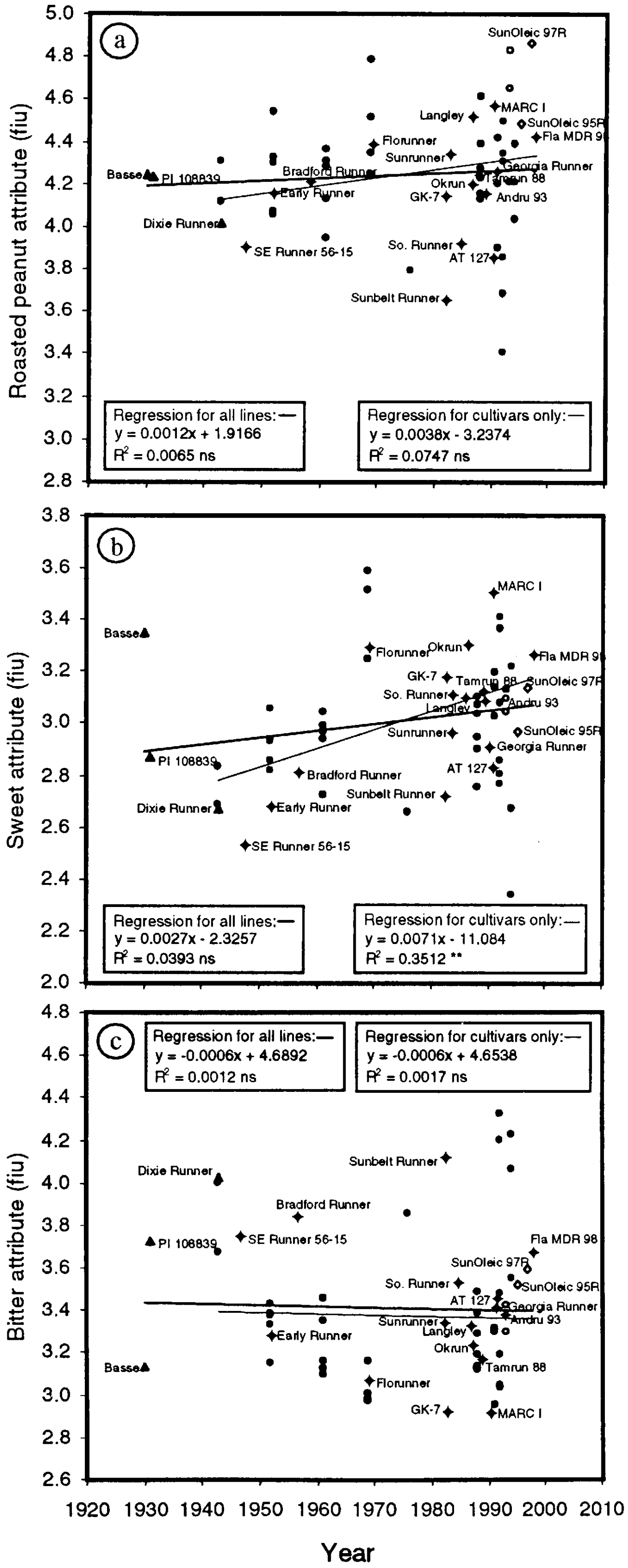

Fig. 2. Least square means for roasted peanut (a), sweet (b), and bitter (c) sensory attributes versus year of release or development for 59 cultivars (✦), ancestral lines (▲), and breeding lines (●) of the runner market type. High oleic cultivars and lines are symbolized with ◇ and ○, respectively.

had the same mean roasted peanut value (4.24 fiu) as lines developed prior to 1980, but the variance in roasted peanut was more than twice as large (two-tailed F = 2.20 with 34 and 23 df, $P < 0.10$). This may reflect the larger sample of unreleased lines from the 1980s and 1990s compared with earlier periods, but it also may reflect the introgression of new germplasm into the runner breeding population, particularly the use of introductions with disease resistance. PI 203396 is the source of resistance to late leaf spot (*Cercosporidium personatum* [Berk. & Curt.] Deighton) in Southern Runner, Florida MDR 98 and other lines from the Univ. of Florida. Additionally, it is the source of resistance to tomato spotted wilt virus (TSWV) in Georgia Green and other lines from the Univ. of Georgia. Its immediate descendants Southern Runner and UF 81206-2 had low scores for roasted peanut attribute (3.93 and 3.86 fiu), and UF 81206-2 had an extremely high bitter score (4.32 fiu). In spite of having a bitter score (3.66 fiu) slightly elevated over the mean of runner types, Florida MDR 98 had higher than average roasted peanut and sweet scores (4.44 and 3.27 fiu, respectively). These comparisons among leaf spot-resistant runner-type lines illustrate the importance of monitoring flavor quality in populations into which exotic germplasm has been introgressed for the purpose of improving some narrow aspect of agronomic value.

At the high end of the distribution of roasted peanut flavor, it appears that the high-oleic acid cultivars and breeding lines developed at the Univ. of Florida are among the best. SunOleic 95R and SunOleic 97R, backcross derivatives of Sunrunner, are superior to Sunrunner in the roasted peanut attribute. Unfortunately, both are highly susceptible to TSWV, so they are unlikely to dominate the seed market in the Southeastern U.S. It remains to be seen if the high oleic trait itself confers superior flavor.

Breeders of runner-type cultivars are fortunate that so much of the U.S. runner breeding population traces to Florunner. Like Florigiant, Florunner so dominated the seed market that it or its components or siblings were widely used as parents in crossing programs. Unlike Florigiant, Florunner has a superior flavor profile and should have passed some of its superior genes to its progeny. However, only a small minority of the runner lines were numerically superior to Florunner in any of the three sensory attributes.

The breeding program at the Univ. of Florida has a history of releasing cultivars that are composites of sibling lines, so-called "multiline" cultivars. In Florida, the multilines are reconstituted at the breeder seed level on a periodic basis. In other states, the multilines were maintained without reconstitution, allowing for shifts in the relative proportions of the constituent lines as the result of sampling and natural selection. This may explain the slight differences observed between the sensory attribute scores for the multiline cultivars Florunner and Early Runner and the average of their respective component lines (Table 2). The same is true of the virginia-type multiline cultivar Early Bunch. In each case, one or more components with a flavor profile superior to the multiline can be identified. Multiline cultivars may have better agronomic stability across variable environments but, from the standpoint of flavor quality, it might have been better for peanut consumers had one of the better tasting components been released rather than the multiline.

Fastigiate Market Type. Spanish and valencia lines have trended toward higher roasted peanut and lower bitter scores over time (Fig. 3a,b,c). The only significant trend across all lines was for decreased bitterness. It should be noted that the fastigiate ancestral lines included in this study (Pearl, Improved Spanish 2B, PI 337396, Small White Spanish, and Spanish 18-38-42) were ancestral primarily to the runner and virginia market types rather than to the spanish and valencia, and there was only one valencia-type cultivar in the sample. Thus, the results for fastigiate cultivars may be more poignant to the spanish market type. Note that Spanish 18-38-42 was selected from the ancestral line Spanish 18-38 and released as the cv. Spanette. Therefore, we have included it both as an ancestral line and as a cultivar. Dropping New Mexico Valencia C from the regression for cultivars results in a significant regression in the sweet attribute ($Y = 0.0140X-24.38$; $R^2 = 0.9112$; $P < 0.05$) and does not materially alter the regressions for roasted peanut and bitter. There has been consistent improvement of flavor in spanish cultivars over the past 60 yr. This is somewhat ironic in view of the decline in the U.S. market for spanish peanuts since the 1970s.

Summary. Flavor data have been rarely collected on breeding lines replicated across environments. A. J. Norden, Florida peanut breeder (deceased), was reputed to have conducted informal sensory testing of breeding lines within his program (D. A. Knauft and H. Wood, pers. commun.). The North Carolina-Virginia Peanut Variety and Quality Evaluation (PVQE) program annually collects and publishes consumer-based flavor data on lines in the final stage of testing prior to release. PVQE data permit comparison only between the proposed release and a single check cultivar chosen on the basis of the salient agronomic features of the test line. Other breeding and testing programs may collect data on the above-mentioned characteristics, but we are unaware of any that publish such data on a regular basis. The database used in this study is the largest and most inclusive known to exist. Because of the difficulty and cost inherent in its measurement, flavor quality based on replicated data has not been used as a criterion for release in any market class. As a consequence, flavor attributes have been used rarely as criteria in the establishment of breeding populations. The relatively inferior flavor profile of virginia-type lines appears to reflect the commercial success of Florigiant and the need to develop CBR-resistant cultivars rather than to any inherent difference in the general profiles of the ancestral virginia-type and runner-type lines. Likewise, the extensive presence of Florunner in the ancestry of current runner breeding populations should help to maintain their average flavor profiles provided the parents used as sources of disease resistance or other necessary agronomic improvements do not carry with them deleterious effects on flavor. The flavor status of the fastigiate market types is

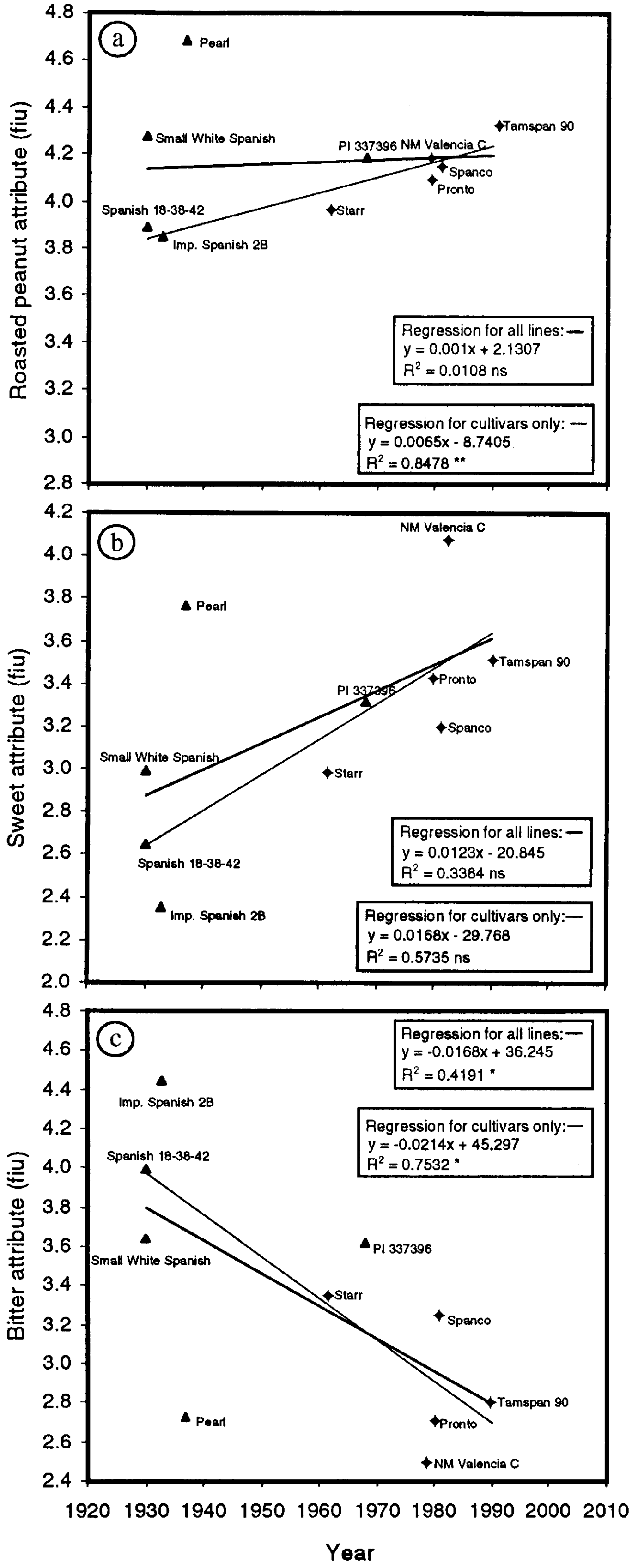

Fig. 3. Least square means for roasted peanut (a), sweet (b), and bitter (c) sensory attributes versus year of release or development for 10 cultivars (✦), ancestral lines (▲), and breeding lines (●) of the fastigiate (spanish and valencia) market types.

good. From this study of cultivars and breeding lines from the past 60 yr, it is apparent that flavor quality should be a consideration in the establishment of breeding populations and that lines selected from those populations monitored for flavor as early in the cultivar development process as possible.

Literature Cited

Isleib, T. G., H. E. Pattee, and F. G. Giesbrecht. 1995. Ancestral contributions to roasted peanut attribute. Peanut Sci. 22:42-48.

Isleib, T.G., and J.C. Wynne. 1992. Use of plant introductions in peanut improvement, pp. 75-116. *In* H.L. Shands and L.E. Weisner (eds.) Use of Plant Introductions in Cultivar Development, Part 2. Crop Science Soc. of America, Madison, WI.

Pattee, H.E., and F.G. Giesbrecht. 1990. Roasted peanut flavor variation across germplasm sources. Peanut Sci. 17:109-112.

Pattee, H.E., and F.G. Giesbrecht. 1994. Adjusting roasted peanut attribute scores for fruity attribute and non-optimum CIELAB L* values. J. Sensory Studies. 9:353-363.

Pattee, H.E., F.G. Giesbrecht, and T.G. Isleib. 1995. Roasted peanut flavor intensity variation among U.S. genotypes. Peanut Sci. 22:158-162.

Pattee, H.E., F.G. Giesbrecht, and R.W. Mozingo. 1993. A note on broad-sense heritability of selected sensory descriptors in virginia-type *Arachis hypogaea* L. Peanut Sci. 20:24-26.

Pattee, H.E., F.G. Giesbrecht, and C.T. Young. 1991. Comparison of peanut butter color determination by CIELAB L*a*b* and Hunter color-difference methods and the relationship of roasted peanut color to roasted peanut flavor response. J. Agric. Food Chem. 39:519-523.

Pattee, H.E., T.G. Isleib, and F.G. Giesbrecht. 1994. Genotype-by-environmental interaction in roasted peanut flavor. Peanut Sci. 21:94-99.

Pattee, H.E., T.G. Isleib, and F.G. Giesbrecht. 1997. Genotype-by-environment interaction in sweet and bitter sensory attributes of peanut. Peanut Sci. 24:117-123.

Pattee, H.E., T.G. Isleib, and F.G. Giesbrecht. 1998. Variation in intensity of sweet and bitter sensory attributes across peanut genotypes. Peanut Sci. 25:63-69.

Pattee, H.E., T.G. Isleib, D.W. Gorbet, F.G. Giesbrecht, and Z. Cui. 2001. Parent selection in breeding for roasted peanut flavor quality. Peanut Sci. 28(in press).

SAS Institute Inc. 1997. SAS/STAT Software: Changes and enhancements through release 6.12. SAS Institute Inc., Cary, NC.