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Effect of High-Oleic Trait and Paste Storage Variables on Sensory Attribute Stability of Roasted Peanuts

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There has been much interest in the effect of the high-oleic acid trait of peanuts on various quality factors since discovery of high levels of oleic acid in a peanut mutant genotype. The trait provides greater oxidative stability for the high-oleic oil and seed. Several research groups have investigated high-oleic peanut oil and roasted peanut flavor characteristics, which were similar within high-oleic lines compared to Florunner. It was observed that some high-oleic lines derived from the Sunrunner cultivar have consistently higher predicted breeding values for roasted peanut attribute than Sunrunner itself. This study investigated if this apparent effect of the trait was an artifact arising from the handling procedures during processing and storage or from flavor fade. High-oleic lines used were derived by backcrossing the trait into existing cultivars, and the comparison of sensory attribute intensity was with the recurrent parent used in backcrossing. Previous comparisons have been between lines differing in more than just oleate content, that is, with widely different background genotypes that could contribute to the differences observed. Differential rates of change in sensory attributes were found in different background genotypes, suggesting that the comparison of high- and normal-oleic lines should be made in common background genotypes as well as in common production and postharvest environments. There was no measurable change in roasted peanut attribute in samples stored at −20 °C over the 63 day duration of this experiment. There were changes in roasted peanut in samples stored at 22 °C, confirming that storage at −20 °C is sufficient for large studies that require multiple sensory panel sessions over a period of weeks.

KEYWORDS: Parentage; roasted peanut attribute; sweet attribute; bitter attribute; *Arachis hypogaea*; genotypes

INTRODUCTION

There has been much interest in the effect of the high-oleic acid trait of peanuts on various quality factors since the discovery of high levels of oleic acid in a select breeding line (F435) by Norden et al. (*1*). This trait was shown to be controlled by two recessive genes (*2*), and one of these genes was common in peanut germplasm (*3*).

The first work using this high-oleic breeding line compared the oxidative stability of extracted oil from the high-oleic line with that extracted from an isogenic sister line with a normal fatty acid composition (*4*). The results demonstrated that the high-oleic peanut oil had a greater oxidative stability than the normal-oleic oil. Later work showed high-oleic roasted peanut seed to have a more stable roasted peanut attribute after 6 weeks of storage at 22 °C and their estimated shelf life to be 2 times longer than that of normal-oleic seed (Florunner) (*5*). Pattee and Knauft (*6*) compared sensory attribute intensities of selected high-oleic breeding lines derived from F435. The select breeding lines had similar attribute intensity compared to Florunner but significantly better roasted peanut attribute intensity compared to NC 7. Within the breeding lines there were no significant differences. Further work on the flavor stability of high-oleic roasted peanut seed was done by Mugendi et al. (*7*) using low relative humidity (∼18%) storage, two high-oleic breeding lines, and Florunner. The flavor quality and flavor stability of the high-oleic breeding lines were not significantly different from each other during storage. The high-oleic breeding lines had better flavor quality and stability than Florunner. Bolton and Sanders (*8*) compared the stability of high-oleic peanuts roasted in high-oleic oil versus normal peanut oil. They found the oxidative stability index (OSI) to be highest for high-oleic peanuts roasted

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Table 1. Mean Squares from Analysis of Variance of the Sensory Attributes Roasted Peanut, Sweet, and Bitter

		fiu[a]									
		roasted peanut		sweet		bitter		stale		painty	
source	df	−20 °C	22 °C	−20 °C	22 °C	−20 °C	22 °C	−20 °C	22 °C	−20 °C	22 °C
background genotype	2	0.66*	0.30	0.31	0.40	0.61	0.55	0.31*	0.19	0.50**	0.43
oleate level	1	0.26	0.38	0.22	0.17	0.02	0.11	1.02**	1.68**	0.70**	0.95*
background genotype × oleate level	2	0.45	0.33	0.10	0.07	0.11	0.11	0.15	0.14	0.19	0.11
reps in background × oleate	12	0.15	0.13	0.13*	0.13*	0.32**	0.26**	0.06	0.10	0.06	0.12
days stored	1	0.38	8.25**	0.48**	0.83**	0.00	0.02	0.29*	3.65**	0.89**	0.00
background × days	2	0.23	0.54	0.09	0.05	0.05	0.00	0.12	0.22	0.26**	0.32*
oleate × days	1	0.36	0.13	0.20	0.20	0.02	0.21	0.45**	1.20**	0.37**	0.18
background × oleate × days	2	0.28	0.09	0.06	0.02	0.06	0.09	0.08	0.31*	0.09	0.03
fruity	1			0.56**				0.35*			
error	30 (29)	0.18	0.30	0.05	0.06	0.10	0.08	0.05	0.08	0.04	0.07

[a] * and ** denote significance at the 5 and 1% levels of probability, respectively.

in high-oleic oil immediately after roasting. The OSI decreased over storage time but the differential between high-oleic and normal roasting oils was maintained throughout the storage period. The stability of high-oleic peanut, sesame, and soybean blends in comparison to normal-oleic peanut, sesame, and soybean blends (*9*) as well as a comparison of the allergenic properties of high-oleic and normal peanuts (*10*) has been investigated.

Pattee and co-workers have shown certain roasted peanut quality sensory attributes to be heritable traits (*11*−*16*). Recently Pattee et al. (*17*) provided some insights into the effects of lines as parents in a breeding program on flavor quality. They observed that the group of high-oleic cultivars and breeding lines derived by backcrossing from the Sunrunner cultivar have approximately the same predicted breeding value for the sweet attribute but were consistently higher in breeding value for roasted peanut attribute than Sunrunner itself. These high-oleic lines had the greatest positive effects on this attribute of any of the lines tested. The objective of this study was to determine if this apparent effect of the high-oleic trait on roasted peanut attribute was an artifact arising from the handling procedures during processing and storage or from different rates of flavor fade (*18*) in normal- and high-oleic peanuts.

MATERIALS AND METHODS

Genotype Resources. In 2000 backcross-derived high-oleic lines and their parents were grown, in three replications, in the peanut region of their origination. Virginia-type lines NC 7, N00090ol, NC 9, and N00092ol were grown at the Peanut Belt Research Station at Lewiston, NC, and at the Upper Coastal Plains Research Station at Rocky Mount, NC. Runner-type lines GK-7 and GK-7 (HOL) were grown at the AgraTech Research Farm, Ashburn, GA. All plots were irrigated, and recommended procedures for weed and disease control, soil fertilization, digging, and harvesting were followed.

Sample Handling. After harvest, the in-shell samples from all plots were shipped to Raleigh, NC, where they were shelled and screened to obtain the sound-mature kernel (SMK) fractions, using a 6.4 × 19.1 mm screen for GK-7 and GK-7 (HOL) and a 6.0 × 25.4 mm screen for all others. SMK fractions were separated using official grading standards for each market type. The SMK fraction from each location entry was placed in controlled storage at 5 °C and 60% relative humidity until roasted.

Sample Roasting and Preparation. The peanut samples were roasted in June and July 2001 using a Blue M Power-O-Matic 60 laboratory oven and ground into a paste, and three aliquots were poured into designated glass jars for storage treatment. The roasting, grinding, and color measurement protocols were as described by Pattee et al. (*19*, *20*).

Storage Treatments. One aliquot was allowed to cool to room temperature and then sensory evaluated. A second aliquot was placed in storage at −20 °C, and the third was held at room temperature and exposed continually to standard fluorescent lighting. Designated jars were removed from the storage treatments after 28 or 63 days, respectively, and sensory evaluated.

Sensory Evaluation. A nine-member trained roasted peanut flavor profile panel at the Food Science Department, North Carolina State University, Raleigh, NC, evaluated all peanut-paste samples using a 14-point intensity scale. Panel orientation and reference control were as described by Pattee et al. (*11*, *19*). Two sessions were conducted each week on nonconsecutive days. Samples were presented in an incomplete block design with four samples per session. Sensory evaluation commenced August 20, 2001, and continued until all samples were evaluated. The averages of individual panelists' scores on sensory attributes were used in all analyses in this study.

Statistical Analysis. Statistical analysis in this study was performed using the general linear models procedure (PROC GLM) in SAS (*21*) to perform analysis of variance, to estimate slopes of regression for storage time under different temperature conditions, and to estimate means adjusted to a common level of all nonclassifying variables. Covariates fruity and roast color were used, as needed, on the basis of the findings of Pattee et al. (*20*, *22*, *23*).

RESULTS AND DISCUSSION

Previous research into the breeding values of 250 peanut genotypes for the sensory attributes roasted peanut, sweet, and bitter indicated that breeding lines with the high-oleic genetic trait had a significantly higher breeding value for the roasted peanut attribute than all of the other genotypes evaluated (*17*). The breeding value for the sweet attribute was neutral for the high-oleic lines. For the purposes of this discussion, breeding value is defined as the effect a line will have on its progeny when used as a parent (*24*). Pattee et al. (*25*) have shown that oxidation of the lipid components is still taking place in roasted peanut paste samples stored at −10 °C over 9 months. The stale attribute had an average rate change of +0.0079 flavor intensity unit (fiu) per day. The roasted peanut attribute, when adjusted for the effects of stale and fruity attributes, had a rate change of −0.0033 fiu day^{-1} at −10 °C, which was attributed to flavor fade. Because the samples for the breeding value study were stored at −10 °C over a 9 month period, three characteristics of the high-oleic lines might explain the observation of a higher roasted peanut attribute: (a) greater oxidative stability, which may slow the increase in stale and painty attributes and the concomitant loss of roasted peanut attribute intensity; (b) reduced rate of flavor fade due to volatilization (*18*); or (c) genetic influence of the high-oleic trait on breeding value for the roasted peanut attribute. Investigation of the first two potential causes of this observation is essential and prerequisite to any future investigation of possible genetic influence. The

Table 2. Average Per-Day Changes in Stale and Painty Sensory Attributes

	fiu day^{-1} [a]			
	stale		painty	
	–20 °C	22 °C	–20 °C	22 °C
av slope	0.0029 ± 0.0012*	0.0101 ± 0.0015**	–0.0050 ± 0.0010**	0.0003 ± 0.0014
slope for high-oleics	0.0064 ± 0.0016**	0.0159 ± 0.0022**	–0.0018 ± 0.0014	–[b]
slope for normal-oleics	–0.0007 ± 0.0016	0.0043 ± 0.0022	–0.0082 ± 0.0014**	–
slope for GK-7	–	–	–0.0103 ± 0.0017**	–0.0055 ± 0.0024*
slope for NC 7	–	–	–0.0023 ± 0.0017	0.0043 ± 0.0024
slope for NC 9	–	–	–0.0023 ± 0.0017	0.0022 ± 0.0024
slope for high-oleic GK-7	–	0.0067 ± 0.0037	–	–
slope for high-oleic NC 7	–	0.0217 ± 0.0037**	–	–
slope for high-oleic NC 9	–	0.0192 ± 0.0037**	–	–
slope for normal GK-7	–	0.0062 ± 0.0037	–	–
slope for normal NC 7	–	0.0081 ± 0.0037*	–	–
slope for normal NC 9	–	-0.0014 ± 0.0037	–	–

[a] * and ** denote slopes significantly different from zero by *t* test at $P < 0.05$ and $P < 0.01$, respectively. [b] Separate slopes not estimated if *F* test of interaction was not significant ($P > 0.05$).

Table 3. Mean Sensory Attribute Intensity Scores for Specific Combinations of Background Genotype, Oleate Level, Storage Temperature, and Time of Storage

background genotype	oleate level	storage: temp, °C	storage: time, days	sensory attribute, fiu: roasted peanut	sweet	bitter	stale	painty
GK-7	high		0	3.59	2.44	2.78	1.93	1.33
GK-7	high	–20	28	3.00	2.22	2.81	1.85	1.11
GK-7	high	–20	63	3.00	2.11	2.78	2.04	1.07
GK-7	high	22	28	2.63	2.07	2.74	1.89	1.33
GK-7	high	22	63	2.78	2.04	3.04	2.33	1.07
GK-7	normal		0	2.89	2.15	3.22	2.33	2.11
GK-7	normal	–20	28	2.70	2.41	2.63	2.00	1.33
GK-7	normal	–20	63	3.33	2.30	2.85	2.07	1.04
GK-7	normal	22	28	2.22	2.19	2.74	2.22	1.67
GK-7	normal	22	63	2.52	2.19	2.78	2.70	1.67
NC 7	high		0	3.59	2.81	2.59	1.52	1.11
NC 7	high	–20	28	3.33	2.15	2.44	1.96	1.15
NC 7	high	–20	63	3.15	2.26	2.52	1.85	1.04
NC 7	high	22	28	2.33	2.19	2.48	2.19	1.37
NC 7	high	22	63	2.22	2.30	2.59	2.89	1.48
NC 7	normal		0	3.93	2.85	2.41	1.70	1.26
NC 7	normal	–20	28	3.37	2.63	2.30	1.70	1.07
NC 7	normal	–20	63	3.30	2.56	2.56	1.89	1.04
NC 7	normal	22	28	2.15	2.26	2.56	2.56	1.48
NC 7	normal	22	63	2.37	2.44	2.37	2.26	1.44
NC 9	high		0	3.67	2.85	2.26	1.33	1.07
NC 9	high	–20	28	2.89	2.67	2.63	1.74	1.15
NC 9	high	–20	63	3.41	2.70	2.44	2.00	1.07
NC 9	high	22	28	2.37	2.52	2.56	2.04	1.56
NC 9	high	22	63	2.48	2.37	2.33	2.56	1.48
NC 9	normal		0	3.30	2.44	2.48	2.19	1.44
NC 9	normal	–20	28	3.22	2.56	2.48	1.81	1.07
NC 9	normal	–20	63	3.41	2.37	2.44	2.07	1.15
NC 9	normal	22	28	2.44	2.48	2.37	2.33	1.85
NC 9	normal	22	63	2.56	2.33	2.37	2.11	1.37

total sample storage period of 63 days covered the length of time necessary to conduct the sensory analysis of a backcross genetic study. A storage temperature of −20 °C was used in the experiment because it has been suggested to stabilize roasted peanut attribute flavor fade (*25*).

Analysis of variance of the sensory attribute scores identified statistically significant ($P < 0.05$) effects of background genotype for roasted peanut, stale, and painty in samples stored at −20 °C (**Table 1**). The difference between high- and normal-oleic lines was detected for stale and painty at both −20 and 22 °C. The significant estimated average per-day changes were -0.0152 ± 0.0023 fiu day^{-1} for roasted peanut from samples stored at room temperature, -0.0037 ± 0.0012 fiu day^{-1} for sweet from samples stored frozen at −20 °C, and -0.0048 ± 0.0012 fiu day^{-1} for sweet from samples stored at room temperature. Mugendi et al. (*7*) also observed a slight decrease in sweetness intensity over a storage time of 10 weeks at 40 °C and ∼18% relative humidity. In contrast to the samples stored at 22 °C, which lost roasted peanut intensity at the rate of one full flavor intensity unit over 66 days, there was no statistically significant degradation in roasted peanut in samples stored at −20 °C over the duration of this experiment.

The significant average per-day changes for stale and painty are given in **Table 2**. The slopes for samples stored at −20 °C are consistent with those reported previously for samples stored at −10 or −22 °C (*25*).

Table 4. Mean Sensory Attribute Intensity for High- and Normal-Oleic Peanuts at Two Storage Temperatures

sensory attribute	storage temp, °C	fiu[a] high-oleic	fiu[a] normal-oleic
roasted peanut	–20	3.29 ± 0.07a	3.27 ± 0.07a
	22	2.85 ± 0.07a	2.71 ± 0.07a
sweet	–20	2.50 ± 0.07a	2.44 ± 0.07a
	22	2.40 ± 0.07a	2.37 ± 0.07a
bitter	–20	2.58 ± 0.11a	2.60 ± 0.11a
	22	2.60 ± 0.10a	2.59 ± 0.10a
stale	–20	1.78 ± 0.05b	2.00 ± 0.05a
	22	2.07 ± 0.06b	2.27 ± 0.06a
painty	–20	1.12 ± 0.05b	1.28 ± 0.05a
	22	1.31 ± 0.07b	1.59 ± 0.07a

[a] Means followed by the same letter within a row are not significantly different by *t* test ($P < 0.05$).

No interaction between background genotype and oleate level was detected in this study. Similarly, no interaction between time of storage and any other factor in the experiment was observed for roasted peanut, sweet, or bitter under either storage temperature. The negative sensory attributes stale and painty, indicative of oxidation of the samples, did show interaction between storage time and oleate level (stale at −20 or 22 °C, painty at −20 °C), between storage time and background genotype (painty at −20 or 22 °C), or among storage time, background genotype, and oleate level (stale at 22 °C). These interactions indicate that the slope of response to storage time varied with the other factors (**Table 2**). The observed interactions, although statistically significant, were generally the result of rather small differences in slope. However, the estimates of response of sensory attributes to storage time are in contrast to assertions that the trait prolongs shelf life by slowing oxidation. Data from this study indicate that stale attribute intensity increased at a faster rate (+0.0159 ± 0.0022 fiu day^{-1}, $P < 0.01$) in high-oleic lines than in normal-oleic lines (+0.0043 ± 0.0022 fiu day^{-1}, NS) in samples stored at 25 °C. A similar differential rate of accumulation of stale occurred in samples stored at −20 °C with high-oleic lines increasing in stale attribute intensity at a rate of +0.0064 ± 0.0016 fiu day^{-1} ($P < 0.01$) while normal-oleic lines remained constant (−0.0007 ± 0.0016 fiu day^{-1}, NS). Most of this differential in slope can be attributed to the changes in stale and painty that occurred in the high-oleic Virginia-type lines (**Table 3**). For the painty attribute, the frozen samples of high- and normal-oleic lines lost intensity at differential rates: −0.0018 ± 0.0014 (NS) for high-oleic lines and −0.0082 ± 0.0014 ($P < 0.01$) for normal-oleic lines. Despite these differential rates of change, the mean sensory attribute intensity for high-oleic lines was 0.2 unit lower than normal-oleic lines for stale and 0.16−0.28 unit lower for painty (**Table 4**), confirming previous reports that the high-oleate trait is associated with less intense oxidative off-flavors (*4*, *5*, *7*).

Our study was unique among studies comparing differences in sensory attributes between normal- and high-oleic lines. The high-oleic lines used in our study were derived by backcrossing the trait into existing cultivars, and the comparison of sensory attribute intensity was with the recurrent parent used in backcrossing. This comparison minimizes the genetic differences between the high-oleic line and the standard with which it is compared. Previous comparisons have been between lines differing in more than just oleate content, that is, with widely different background genotypes that could contribute to the differences observed. We found differential rates of change in sensory attributes in different background genotypes (**Tables 1** and **2**), suggesting that the comparison of high- and normal-oleic lines should be made only in common background genotypes.

To address the objective of this experiment, that is, to determine whether loss of intensity of the roasted peanut attribute during storage at −20 °C might be a factor contributing to variation attributed to other factors in sensory panel evaluations conducted over a period of several weeks, there was no statistically significant change in roasted peanut in samples stored at −20 °C over the 63 day duration of this experiment. There were changes in roasted peanut in samples stored at 22 °C, confirming that storage at −20 °C is necessary for studies of sufficient size to require multiple sensory panel sessions over a period of weeks. At −20 °C, differential oxidative stability or rates of flavor fade are not a factor in differences in roasted peanut attribute intensity between normal- and high-oleic lines.

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