Sensory Quality Evaluation of Market-Grade-Sized Red Testa Seed Associated With TSWV Infection from Peanut Genotypes of Varying Resistance Levels[1]

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ABSTRACT

With the increasing impact of tomato spotted wilt tospovirus (TSWV) on peanut production, concerns have been voiced by peanut processors that this disease has a negative impact on roasted peanut flavor quality. A descriptive sensory panel evaluated selected TSWV-resistant [Florida MDR 98, C-99R, UF97318] and susceptible (Florunner) genotypes for sensory quality differences by comparing market-grade sized (jumbo, medium, and No. 1 runner) red testa and normal seed from plants grown at two sites—Lewiston, NC and Marianna, FL. The triangle difference test and descriptive evaluation were performed on roasted peanut paste samples. Panelists were able to discern differences between pastes from normal and red testa seeds which most often were discerned in UF97318. Discernment became more pronounced as the market-grade size decreased from jumbo to medium to No. 1. Intensity of roasted peanut and sweet attributes was highest in Florida MDR 98 and lowest in UF97318. It was more difficult to achieve a constant roasted paste color in red testa than in normal samples. However, this difference had no effect on panelist's evaluation of sensory attributes. A specific factor enabling the panelists to discern differences between red testa and normal roasted paste samples was not identified. It is probable that the ability to discern differences between red testa and normal samples was the result of an accumulation of minor flavor differences.

Key Words: *Arachis hypogaea* L., flavor, tomato spotted wilt virus.

Infection of the peanut (*Arachis hypogaea* L.) crop throughout the U.S. peanut-growing regions by tomato spotted wilt tospovirus (TSWV) has been increasing in importance as a production problem. For many peanut growers, TSWV is their most important disease problem. There are few effective tactics for management of this disease (Culbreath *et al.*, 1997). The most often used management practice is use of a high seeding rate. Apart from this, development of cultivars with resistance to TSWV seems to have the most potential for minimizing the effects of this disease.

Breeding for disease resistance often requires introduction, evaluation, and hybridization with exotic plant introductions, whose genetic influences on flavor or other quality characteristics are unknown. The work of Pattee and coworkers (Pattee *et al.*, 1998; Isleib *et al.*, 2000) indicated that cultivars developed for resistance to Cylindrocladium black rot (CBR, *Cylindrocladium parasiticum* Crous, Wingfield & Alfenas) have lower sweet and roasted peanut intensities and higher bitter intensity than susceptible large-seeded virginia cultivars. However, they did not observe similar relationships in genotypes with resistance to late leaf spot.

With the increasing impact of TSWV on peanut production, peanut processors have voiced concern that this disease may have a negative impact on peanut flavor quality. Sanders *et al.* (1994) studied the quality characteristics of medium grade-size red testa peanuts from TWSV-infected plants of the Florunner cultivar and found statistically significant but not meaningful descriptive differences. The red testa is indicative of infection by TSWV (Demski and Reddy, 1997; see color plate 102 for comparative illustration). However, sweet intensity was lower and bitter intensity higher in red testa seed than in normal seed. In sizing lots of normal and red testa seed, they did find that red testa seed occurred in higher percentages in the 7.1-mm and lower fractions.

The objectives of this study were to evaluate sensory attributes in selected TSWV-resistant and susceptible genotypes and compare market-grade sized red testa and normal seed from TSWV-infected plants for sensory quality differences.

Materials and Methods

Genotype Resources. Genotypes C-99R (UF94320) (Gorbet and Shokes, 2000b), UF97318, and Florunner were grown in Marianna, FL and Lewiston, NC as a part of the 1998 Uniform Peanut Performance Test (UPPT) (Branch, 1999). Florida MDR 98 (Gorbet and Shokes, 2000a) was grown at Marianna, FL in 1998 in the same field as the UPPT but as part of another variety test. Plants were grown and harvested under standard recommended procedures for the specific location.

Sample Handling. Seed samples were shelled and screened into No. 1, medium, and jumbo runner-market grade lots. The characteristic red testa seed from TSWV-infected plants (Sanders *et al.*, 1994) were then handpicked from each screened lot. Although testa color is an imperfect

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method of identifying TSWV-infected seeds, it was not feasible to perform an ELISA test on each individual seed, and the color difference is sufficient that shellers or processors could sort seeds on that basis. The two segregated sublots of each market grade were then designated as 'red testa' and 'normal' market-grade lots. The Florida location lots were the first processed, shipped to Raleigh, NC, and placed in controlled storage at 5 C and 60% RH. These lots were used as standards for the North Carolina lot segregation. Following segregation, all lots were returned to controlled storage until roasted.

Sample Roasting and Preparation. The samples were roasted in May 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). The roast color of the peanut paste was evaluated as CIELAB L^*. Possible conversion of CIELAB L^* values to the more common Hunter L by the subtraction of 7 color units is described by Pattee *et al.* (1991).

Sensory Evaluation. A seven-member, trained, roasted peanut profile panel at the Food Science Dept., North Carolina State Univ., Raleigh, NC, was used to evaluate all peanut paste samples. A triangle difference test was conducted on red testa vs. normal seed samples within each genotype for each grade size and location. An incomplete block experimental design was used for order of testing. Two triangle difference tests (Chambers and Wolf, 1996) were conducted at each panel session. Two sessions were conducted each week on nonconsecutive days for all analyses. The same panel conducted a descriptive sensory analysis of all peanut paste samples using a 14-point intensity scale. Panel orientation and reference control were as described by Pattee and Giesbrecht (1990) and Pattee *et al.* (1993). Sensory evaluation commenced the first week of June 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. Under the null hypothesis that panel members could not distinguish between paste made from red testa seed and control seed, there is a one-third probability that an individual will identify the odd member in the set of three correctly. If this is repeated n independent times, the total number of correct identifications will follow the binomial probability distribution. By evaluating the distribution, you determine if the observed count is sufficiently large to be deemed statistically significant and reject the null hypothesis of no ability to discriminate. Data from the triangle difference test were evaluated using the binomial probability distribution (SAS Inst., 1997). Contingency tables were constructed to compare the rates of successful discernment in different germplasm, locations, or grades. PROC GLM in SAS (SAS Inst., 1997) was used to perform the statistical analyses of the sensory attribute data.

Results and Discussion

Triangle Tests Comparing Red Testa and Normal Seed. The effect of TSWV on the flavor quality of roasted peanuts was evaluated using a selected set of peanut germplasm having resistance and a susceptible standard. The standard susceptible cultivar was Florunner and the germplasm with resistance were Florida MDR 98, C-99R, and UF 97318 (an advanced breeding line in the Florida program). The initial challenge was to detect a sufficient difference in sensory quality. The results from the triangle test (Table 1) indicate that the probability that an individual will identify the odd member in the set of three correctly was more than the one-third expected if the individual could taste no difference. Pooled across germplasm, location, and grade, panelists were able to discern a flavor difference between red testa and normal seed 60% of the time (Table 1). This or a higher rate of success would be observed with a probability of less than one in a trillion if the true probability of successful discernment were only one-third as assumed in the null hypothesis. Contingency tables (not shown) indicated that the success rate was not influenced by germplasm (χ^2 = 7.08 with 3 df, P = 0.069), location (χ^2 = 0.26 with 1 df using the Yates correction, P = 0.606), or grade (χ^2 = 5.49 with 2 df, P = 0.064). There was a trend to better discernment going from jumbo to medium to No. 1 kernels. There also was slightly better discernment in UF 97318 (71% correct) followed by C-99R (64%),

Table 1. Pooled sensory differences between red testa and normal seeds detected by triangle difference test.

Comparison	Detected difference	Total comparisons	Observed success rate	$P\{X \geq x\}$[a]
Pooled across germplasm, location, and grade	202	336	0.601	.0000
Germplasm pooled across location and grade				
Florida MDR 98	44	77	0.571	.0000
Florunner	63	119	0.529	.0000
UF 97318	50	70	0.714	.0000
C-99R	45	70	0.643	.0000
Location pooled across germplasm and grade				
Marianna, FL	149	252	0.591	.0000
Lewiston, NC	53	84	0.631	.0000
Grade pooled across germplasm and location				
Jumbo kernels	66	126	0.524	.0000
Medium kernels	93	147	0.633	.0000
No. 1 kernels	43	63	0.683	.0000

[a]Binomial probability that the observed number of successes or more would be obtained if the true success rate were 1/3.

Florida MDR 98 (57%), and Florunner (53%). This order of discernment follows the order of decreasing resistance to TSWV, but all three of the TSWV-resistant genotypes derive some of their resistance from the same source, PI 203396.

In 13 out of 20 specific combinations of germplasm, location, and grade, the triangle test results (Table 2) indicate the rate of successful discernment of the odd

Table 2. Sensory differences between red testa and normal seeds detected by triangle difference test for combinations of germplasm, location, and grade.

Germplasm	Location	Grade	Detect difference	Total observations	Success rate	P{X ≥ x}[a]
Florida MDR 98	Marianna, FL	Jumbo	18	35	0.514	.0204
		Medium	22	35	0.628	.0003
		No. 1	4	7	0.571	.1733
Florunner	Marianna, FL	Jumbo	13	28	0.464	.1039
		Medium	16	28	0.571	.0082
		No. 1	11	21	0.524	.0557
UF 97318	Marianna, FL	Jumbo	8	14	0.571	.0576
		Medium	15	21	0.714	.0004
		No. 1	7	7	1.000	.0005
C-99R	Marianna, FL	Jumbo	15	28	0.536	.0216
		Medium	14	21	0.667	.0018
		No. 1	6	7	0.857	.0069
Florunner	Lewiston, NC	Jumbo	2	7	0.286	.7366
		Medium	10	21	0.476	.1248
		No. 1	11	14	0.786	.0007
UF 97318	Lewiston, NC	Jumbo	5	7	0.714	.0453
		Medium	11	14	0.786	.0007
		No. 1	4	7	0.571	.1733
C-99R	Lewiston, NC	Jumbo	5	7	0.714	.0453
		Medium	5	7	0.714	.0453

[a]Binomial probability that the observed number of successes or more would be obtained if the true success rate were 1/3.

sample was significantly greater than one-third. Seed supply limited the number of difference tests that could be performed within some combinations, resulting in poor precision of the test for those combinations. This is illustrated by the 57% success rate for Florunner-Marianna-medium grade-sized seed (16 successes out of 28 difference tests) being significantly greater (P = 0.008) than the hypothetical one-third success rate, and the same observed success rate for UF 97318-Marianna-jumbo grade-sized seed of (eight successes out of 14 tests), which had a significance of P = 0.058. This success rate (57%) for Florida MDR 98-Marianna-No. 1 grade-sized seed of (four successes out of seven tests) did not approach significance even at the 10% level of probability (P = 0.173).

Sensory Attribute Intensity in Red Testa and Normal Seed. Having found that there was a discernable sensory difference between red testa and normal seed, the second challenge was to determine the basis for the discernment. Both Pattee *et al.* (1991) and Pattee *et al.* (2000) discussed the importance of roast color to roasted peanut quality sensory responses. Therefore, roast color was included as a response variable in the analysis of variance. The sensory quality attributes chosen for evaluation were roasted peanut, overroast, underroast, fruity, sweet, bitter, tongue/throatburn, and astringent. Definitions for these attributes have previously been given in Pattee *et al.* (1995). In previous publications, roast color, and fruity attribute have been used as covariates in the analysis of other sensory attributes (Pattee and Giesbrecht, 1994). In these data, the variation in roast color and fruity attribute was associated with experimental design effects, making the two characteristics unsuitable for use as covariates.

Based on the analysis of variance (Table 3), roast color was influenced by test location (P < 0.01), testa-color (defined as red testa vs. normal seed color) (P < 0.01), and interaction between genotype and testa color (P < 0.05). Peanuts from Marianna, FL roasted to nearly optimum roast color while those from Lewiston, NC were nearly two color units darker than optimum on average (Table 4). This difference in roast color may reflect general differences in maturity between samples from the two locations (Sanders *et al.*, 1989). It should be noted that even though the optimum roast color difference between the locations is significant, it is only marginally outside the ± 2 color unit tolerance level and the range of difference did not affect the sensory intensity of the roasted peanut attribute (Table 4). The genotype-by-testa-color interaction was caused by differential effect of testa color on the four genotypes (Table 5). There was no difference between the roast color of normal and red testa seed for Florunner and Florida MDR 98, but the red testa seed of C-99R and UF 97318 roasted substantially darker (1.5 to 2.2 CIELAB L* units) than the normal seed. The large effect of testa-color on these two genotypes caused the significance of the main effect. Again, these color differences may be

Table 3. Mean squares from analysis of variance of roast color and sensory attributes measured on four genotypes differing in their resistance to tomato spotted wilt virus.

Source	df	Roast color[a]	Roasted peanut	Over-roast	Under-roast	Fruity	Sweet	Bitter	Tongue/ throat burn	Astrin-gent
		CIELAB L*	fiu							
Test location	1	119.73**	0.02	0.22	0.01	0.31*	0.64*	1.85**	1.09**	0.62**
Genotype	3	3.17	0.50*	0.02	0.21	0.38**	0.56**	0.20	0.21†	0.09
Grade	2	0.02	1.24**	0.03	0.10	1.95**	0.46*	0.06	0.02	0.02
Genotype x grade	6	2.25	0.38*	0.13	0.30	0.14*	0.22†	0.12	0.11	0.04
Testa-color	1	12.36**	0.09	2.23**	1.44*	0.38*	2.84**	2.27**	0.73**	0.74**
Genotype x t-color	3	6.02*	0.10	0.07	0.09	0.07	0.08	0.15	0.04	0.08
Grade x t-color	2	4.93†	0.00	0.03	0.08	0.12	0.23	0.01	0.06	0.10
Geno x grade x color	6	1.74	0.03	0.14	0.15	0.02	0.10	0.10	0.07	0.11
Error	70	1.75	0.13	0.15	0.23	0.06	0.12	0.13	0.08	0.08

[a]Roast color relative to an optimum CIELAB L* value of 58.3.

†,*,**Denote mean squares significant at the 0.10, 0.05, and 0.01 levels of probability, respectively.

Table 4. Adjusted main-effect means and standard errors for roast color and sensory attributes measured on four genotypes differing in their resistance to tomato spotted wilt virus.[a]

Source	Roast color[b]	Roasted peanut	Over-roast	Under-roast	Fruity	Sweet	Bitter	Tongue-burn	Astrin-gent
	CIELAB L*	fiu							
Test location									
Marianna, FL	0.70±0.18a	3.39±0.05[c]	1.46±0.05	2.88±0.07	1.44±0.03b	2.48±0.05b	3.25±0.05a	2.54±0.04a	3.31±0.04a
Lewiston, NC	-2.10±0.31b	3.36±0.08	1.34±0.09	2.90±0.11	1.59±0.06a	2.68±0.08a	2.90±0.08b	2.28±0.06b	3.11±0.07b
Genotype									
Fla MDR 98	-0.29±0.41	3.65±0.11a	1.44±0.12	2.97±0.15	1.75±0.08a	2.85±0.10a	3.24±0.11	2.42±0.09	3.16±0.09
Florunner	-0.36±0.23	3.39±0.06b	1.41±0.07	2.77±0.08	1.42±0.04b	2.55±0.06b	3.06±0.06	2.48±0.05	3.26±0.05
C-99R	-1.17±0.39	3.23±0.11b	1.35±0.12	2.99±0.14	1.38±0.07b	2.56±0.10bc	2.93±0.11	2.23±0.08	3.12±0.08
UF 97318	-0.97±0.32	3.23±0.09b	1.39±0.10	2.84±0.12	1.52±0.06b	2.35±0.08c	3.08±0.09	2.50±0.07	3.30±0.07
Grade									
No. 1	-0.72±0.40	3.16±0.11b	1.35±0.12	2.96±0.14	1.90±0.07a	2.77±0.10a	3.02±0.11	2.37±0.08	3.25±0.08
Medium	-0.70±0.22	3.34±0.06b	1.43±0.07	2.89±0.08	1.41±0.04b	2.52±0.06b	3.08±0.06	2.44±0.05	3.20±0.05
Jumbo	-0.67±0.25	3.62±0.07a	1.42±0.07	2.82±0.09	1.24±0.05c	2.45±0.06b	3.13±0.07	2.42±0.05	3.18±0.05
Testa-color									
Normal	-0.26±0.25a	3.34±0.07	1.21±0.07b	3.04±0.09a	1.59±0.05a	2.79±0.06a	2.89±0.07b	2.30±0.05b	3.10±0.05b
Red	-1.14±0.25b	3.41±0.07	1.58±0.07a	2.74±0.09b	1.44±0.05b	2.37±0.06b	3.27±0.07a	2.52±0.05a	3.32±0.05a

[a]Means followed by the same letter within columns by source are not significantly different by protected t-test at P≤0.05. Means followed by no letters are not significantly different by F-test.

[b]Roast color relative to an optimum CIELAB L* value of 58.3.

Table 5. Two-way interaction means for roast color and roasted peanut and fruity sensory attributes.[a]

	Roast color[b]		Roasted peanut			Fruity		
Genotype	Normal	Red testa	No. 1	Medium	Jumbo	No. 1	Medium	Jumbo
	Adj. CIELAB L*		------------ fiu ------------			------------ fiu ------------		
Fla MDR 98	-0.38±0.55aα	-0.21±0.55aα	3.04±0.26cα	3.62±0.12bα	4.28±0.12aα	2.35±0.18aα	1.60±0.08bα	1.29±0.08 cα
Florunner	-0.41±0.33aα	-0.31±0.32aα	3.21±0.11bα	3.32±0.10baβ	3.65±0.11aβ	1.67±0.08aγ	1.28±0.07bβ	1.30±0.08 bα
C-99R	-0.06±0.54aα	-2.28±0.54bβ	3.07±0.26aα	3.26±0.12aβ	3.35±0.12aβγ	1.63±0.18aβγ	1.38±0.08aaβ	1.14±0.08 bα
UF 97318	-0.20±0.46aα	-1.74±0.46bβ	3.34±0.18aα	3.14±0.13aβ	3.22±0.15aγ	1.96±0.12aαβ	1.37±0.09bαβ	1.22±0.10 bα

[a]Means followed by the same letter for a trait within a row are not significantly different (P < 0.05) by t-test. Means followed by the same Greek letter for a trait within a column are not significantly different (P < 0.05) by t-test.

[b]Roast color relative to an optimum CIELAB L* value of 58.3.

due to differences in maturity, perhaps indicative of retardation of maturation in TSWV-infected plants.

All sensory attributes except roasted peanut were significantly (P < 0.05) affected by testa color—i.e., there was a statistically significant difference between red testa and normal seed (Tables 3 and 4). The flavor profile of the red testa peanuts was generally inferior to the normal peanuts. Red testa peanuts had lower fruity, higher overroast, lower underroast, lower sweet, higher bitter, higher tongue/throat burn, and higher astringent values. In all cases, the statistically significant difference was less than the 0.5 flavor intensity (fiu) unit detectable by an individual panelist. Therefore, one cannot ascribe the discernable difference in sensory quality by triangle testing to any one particular attribute. It may have been the combination of small differences in several attributes that allowed the panelists to differentiate the flavors of normal and red testa seed.

Test location affected several sensory attributes (Table 3). Peanuts from Lewiston, NC had higher fruity, higher sweet, lower bitter, lower tongue/throat burn, and lower astringent scores than peanuts from Marianna, FL (Table 4). These differences have not been observed consistently between peanuts from the two sites (data not shown). The flavor difference of one location compared to another varies with year. Genotype and grade influenced roasted peanut (P < 0.05 and P < 0.01, respectively), fruity (P < 0.01 for both), and sweet (P < 0.01 and P < 0.05, respectively) (Table 3). Among the four genotypes (Table 4), Florida MDR 98 was highest in roasted peanut and sweet intensities in spite of having the highest average fruity intensity. In previous studies, there has been a negative relationship between fruity and roasted peanut with approximately one fiu of decrease in roasted peanut for each two units of increase in fruity (Pattee *et al.*, 1990). Based on this relationship, one might expect a further improvement of approximately 0.15 fiu of the roasted peanut intensity of Florida MDR 98 if the fruity intensity could be reduced to the average level of the other genotypes. Increase in grade size resulted in a general improvement of flavor profile through consistent reduction in fruity and increase in roasted peanut attributes (Table 4). These observations are consistent with those of Pattee *et al.* (1989, 1990) that showed similar patterns for fruity and roasted peanut attributes across grades in both runner and virginia market-type peanuts. Reduction in sweetness with larger grades is consistent with the observations of McMeans *et al.* (1990) that showed sugar content to decrease with larger grades of Florunner. As was found for roast color, there was little interaction detected among factors for sensory attributes; however, genotype-by-grade interaction was detected for roasted peanut (P < 0.05) and fruity (P < 0.05). Neither UF 97318 nor C-99R had any significant change in roasted peanut intensity across grades, while Florida MDR 98 and Florunner data showed the change that has been reported in previous work (Pattee *et al.*, 1989, 1990). For fruity, the interaction arose from the change in variation among the genotypes at the different grades. There was significant genotypic variation among No. 1 kernels, less among mediums, and none among jumbos. Perhaps the most important aspect of interaction in sensory attributes is the absence of significant interactions involving testa color and other factors. The effect of testa color on sensory attributes appears to be independent of genotype and grade.

Conclusions

Based on triangle difference tests, sensory panelists were able to discern differences in the flavor profiles of peanut paste ground from seeds with and without the red testa which is characteristic of infection with TSWV. Panel discernment was independent of genotype, location, and grade. Sensory scores indicated that the red testa peanuts had a generally inferior flavor profile in comparison to the normal peanuts. Sensory attributes overroast, underroast, sweet, bitter, tongue/throatburn, and astringent all differed between the red testa and normal peanuts. However, the difference for any given sensory attribute was too small to be detected by an individual panelist. The panelists' ability to discern between the flavor profiles of red testa and normal peanuts was probably due to the combination of the small differences. The absence of interaction of testa color with other experimental factors indicated that the effect of testa color was independent of genotype and grade in each of the sensory attributes scored. These results suggest that the general flavor quality of products made from peanuts grown in areas where TSWV is a problem could be improved by eliminating the red testa peanuts from lots before processing.

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