Roasted Peanut Flavor Variation Across Germplasm Sources[1]

Harold E. Pattee*[2] and Francis G. Giesbrecht[3]

ABSTRACT

Roasted flavor is a critical factor in the acceptance of a peanut cultivar. A three-year study was made on the variation in roasted peanut flavor intensity of U.S. peanut cultivars and advanced breeding lines. An initial set of 83 entries was reduced to 71 by removing samples that showed evidence of extraneous environmental conditions, immaturity, and handling or improper sample preparation effects. All entries for the cv. New Mexico Valenicia C, representing the valencia market type, were lost because of improper roasting or intense fruity flavor. Florigiant, Florunner, and Pronto were used as comparison standards for roasted peanut attribute values in evaluating the virginia, runner, and spanish market types, respectively. The positive estimated difference between control and test germplasm sources was largest within the virginia type, with a least-square mean difference of +1.4 for roasted peanut attribute intensity. Spanish types were next with a positive estimated difference of +1.3, and runner types were lowest with a positive estimated difference of +0.5. Broadsense heritability for the roasted peanut attribute among germplasm sources was determined to be 24%, suggesting a potential for improving the roasted peanut attribute level through proper breeding stratagems.

Key Words: Roasted flavor, *Arachis hypogaea*, heritability, groundnut, market-types

In 1986 about 69% of the edible supply of shelled peanuts in the United States were roasted (1). It is this roasting process which converts the peanut seed from its slightly sweet, green "beany" flavor in the raw state to a flavor that is delicate, uniquely nutty, and widely enjoyed. Research into the origin of this delicate and uniquely nutty flavor for peanuts has shown that amino acids, a peptide, and carbohydrates in an oil medium are the precursors to roasted peanut flavor (8, 9, 12). Reviews on the various aspects of roasted peanut flavor and parameters which affect it can be found in the literature (2, 15, 20).

Knauft et al. (7) have reviewed specific breeding objectives for peanuts which have been and are being undertaken, as well as progress made in meeting these objectives. Although little, if any, research has been done on the variation in roasted peanut flavor intensity among peanut germplasm sources, research has been done on several components of the peanut that may be associated with flavor. Variations among peanut genotypes have been studied concerning protein and free amino acids contents (5, 24, 26, 27) and carbohydrates (3, 14, 28). Amino acid composition variation among selected genotypes has been investigated by Young (26). The most widely investigated component across peanut genotypes is oil and fatty acid composition (13, 19). Varietal differences in the stereospecificity of triacylglycerols has also been examined (21, 25).

The objectives of this study were (1) determine the variability in roasted peanut flavor intensity across a wide range of peanut cultivars and breeding lines, (2) obtain heritability estimates for selected sensory attributes, (3) document the variations between locations and across years for future studies to take into consideration, and (4) ultimately provide a difference estimate of roasted peanut flavor intensity which can be used by peanut breeders as a first test for the existence of significant differences in roasted peanut flavor between breeding lines.

Materials and Methods

The individual germplasm samples used in this study were obtained from peanut breeding programs in Florida, Georgia, North Carolina, Oklahoma, Texas and Virginia and represent nearly all commercially available cultivars and each market type grown in the United States. The advanced breeding lines for the 1986 crop year were obtained from the above represented states and selected cultivars and breeding lines grown in Georgia and Virginia during 1987 and 1988. All samples were obtained from plants grown and harvested under standard recommended procedures for the specific location. Replication in this study was obtained by replication of selected entries across locations in 1986 and repeating selected entries from 1986 in 1987 and 1988 for both locations.

After shelling, the sound mature kernel (SMK) fraction was obtained by screening over the appropriate screen size for the given market type. An approximate 1,000 g-SMK fraction was shipped to Raleigh, NC during February following harvest and placed in controlled storage at 5 C and 60% R. H. until roasted and evaluted. Peanut samples were roasted during June and July of that year using a Blue M "Power-O-Matic 60" laboratory oven. A 400 g roasting sample was equally divided among eight compartments within the oven. Roasting time varied from sample to sample but the roasting temperature was held constant at 160 C. Immediately after cooling, using forced room temperature air, the peanuts were blanched (6) and then ground into peanut paste using an Olde Tyme peanut butter mill, Olde Tyme Food Products, 143 Shaker Road, E. Long Meadow, Mass. 01028. Two random subsamples of the peanut paste were put into Falcon No. 1007, 60 x 15 mm, disposable petri dishes, covers placed to retard any oxidative processes and the three color-reflectance values, CIELAB L*, a*, b*, determined immediately. The remainder of each ground peanut paste sample was placed into a glass jar, sealed and frozen at -20 C until needed for sensory evaluation.

The CIELAB L*, a*, b* values were determined using a Minolta Chroma Meter II CR-100, Minolta Camera Co., Ltd., Osaka, Japan. A d/o illuminating system and an 8 mm reflectance port were used. The illumination was supplied by a D6500 K light source. the spectral responses approximate the CIE Colorimetric Standard Observer. Each subsample was read once at two different locations on the sample container. The instrument was standardized at the beginning of each day and before the start of each afternoon session with the standard white tile supplied with the instrument. An in-depth discussion of the color measurement protocol used in this study is given by Pattee et al. (16).

Sensory Evaluation

An eight-member trained roasted peanut flavor profile panel at the Food Science Department, North Carolina State University, Raleigh, NC evalutated all peanut paste samples using 14-point intensity scales. An orientation session was conducted at the beginning of each peanut-crop-year evaluation in which the panel reviewed the definition of the following roasted peanut sensory attributes: painty, stale, roasted peanut, overroast, underroast, sweet, fruity, mold, petroleum, bitter, astringent, throat/tongue burn and nutty and then compared selected experimental peanut paste samples to a peanut butter control sample. A handout containing the

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[2]Research Chemist, U. S. Department of Agriculture, Agricultural Research Service, Department of Botany, North Carolina State University, Box 7625, Raleigh, NC 27695-7625.

[3]Professor, Department of Statistics, North Carolina State University, Box 8203, Raleigh, NC 27695-8203.

*Corresponding author.

defined roasted peanut sensory attributes and the control sample with ratings was presented to the panel at each session. Two sessions were conducted weekly. Panelists evaluated six samples per session the first year and five samples per session in subsequent years. Samples were presented in a randomized order.

Statistical Analysis

All statistical analysis in this study was performed using procedures in the SAS (23) system, version 6. It should be noted that the statistical design of this study provides large error estimates and thus conservative estimates on statistical significance. The averages of individual panelists' scores on sensory attributes were used in all analyses.

Results and Discussion

Use Justification Sound Mature Kernel Fraction For Flavor Analysis

Previous flavor research has shown that virginia and runner-type peanuts 7.14 mm or larger do not have significant relations between size and roasted peanut attribute intensity (17, 18) and the difference in roasted peanut intensity between Medium and No. 1 market grades is 2.2 and 2.0 units for virginia and runner peanuts. Pattee and Young (19) have shown 6.35 and 6.74 mm size seed are not significantly different in flavor score than 7.14 mm seed and 5.95 mm seed contribute primarily to the flavor reduction in No. 1 virginia peanuts. Based on shell-out data, seed size distribution data, and minimum screen size for No. 1 runner and virginia (10, 11) the maximum percent No. 1 in an SMK fraction would be about 15 and 25 percent, respectively. Thus, flavor reduction from the maximum potential due to the No. 1 fraction would be about 0.3 and 0.6 units, respectively. Since we made comparisons within market type this reduction has no impact for this study. If the variation were 10 percent the flavor reduction variation would be about 0.03 and 0.06, respectively. Since the panel only gives flavor intensity units in whole numbers it is evident that the variation in the SMK fraction due to variation in the No. 1 grade component would not be significant and the use of the SMK fraction is justified.

Raw Data Evaluation-Statistical Considerations

Interaction among the sensory attributes roasted peanut, overroast, underroast and fruity has been demonstrated (16, 18) and suggests that the raw data should be evaluated for the effects of these factors on the roasted peanut attribute. Improperly roasted samples, which produce abnormal values for overroast and underroast and are indicated by CIELAB L* color values <56 or >62 of the roasted peanut paste (16), were removed by limiting the CIELAB L* color values to within this range (Table 1). The removal of these samples reduced the variability in the data and made the true differences due to peanut type and germplasm more apparent. This consistently reduced the coefficient of variation in all individual-year data sets and the combined-across-years data set. Fruity attribute intensities of three or above can also cause a reduction in the roasted peanut attribute response (18). The fruity attribute may arise from exposure to extreme environmental conditions, high temperatures during curing, and/or immaturity of the seed (17, 18, 22). Samples rated by the panel with a fruity attributed of 3 or above were also deleted. This reduced the c.v. values in all but the 1988 data set (Table 1). In the combined data set (which will be the basic data set unless otherwise stated) the removal of the improperly roasted samples and samples with fruity attribute scores over three led to an appreciable reduction of variability in the roasted peanut attribute.

One of the unfortunate results of removal of these samples was the complete elimination of all cv. New Mexico Valencia C entries. Although New Mexico Valenica C was included at all locations in 1986, all entries were dropped because of the roast color, and in 1987 and 1988 they were dropped because of the fruity attribute level. The elimination of all entries from New Mexico Valencia C suggests that a further look at the valencia-type would be appropriate.

The changes in the data set c.v. values illustrate the importance of understanding the interactions between various sensory attributes. Although sensory evaluation of roasted peanut products has been undertaken for decades this is probably the first demonstration of the importance of precise control of the degree of roast and of the necessity to constrain interacting sensory attributes in order to maximize the roasted peanut attribute effect.

Table 1. Influence of reduced variable interaction on the Coefficient of Variation.

Constrained Variable	Data Set	No. Obs.	Germplasm Entries	Coeff. of Variation
None	1986	115	74	11.37
CIELAB L*	1986	93	65	9.67
Fruity	1986	105	69	9.82
L* + Fruity	1986	88	62	9.85
None	1987	39	23	15.82
CIELAB L*	1987	32	22	10.54
Fruity	1987	34	19	13.99
L* + Fruity	1987	28	19	7.71
None	1988	60	22	10.94
CIELAB L*	1988	41	22	7.61
Fruity	1988	49	20	11.48
L* + Fruity	1988	34	19	8.25
None	Combined	214	83	11.96
CIELAB L*	Combined	166	75	10.13
Fruity	Combined	188	78	11.27
L* + Fruity	Combined	150	71	9.58

Comparative Variation of Roasted Peanut Attribute Among Germplasm

In order to make comparisons among germplasm the major production cultivars, Florigiant (virginia), Florunner (runner) and Pronto (spanish) were designated as control germplasm for each of the market-types and the statistical comparisons were made within market-type. Least-square mean (estimates adjusted for location and year effects) values for the roasted peanut attribute were determined for each germplasm. Both the unadjusted and least -square means are presented for informational purposes but only the least-square means were used to determine differences (Tables 2, 3 and 4).

At the present time there is no standard improvement guideline for roasted peanut flavor intensity to assist peanut breeders in making a decision regarding how much improvement would be needed to significantly effect the commercial product. An informal survey of peanut butter manufacturers has indicated an improvement of +0.5 units, on a 14-point scale, would be required for a significant effect on the commercial product. Thus, it is assumed a minimum improvement of +0.5 is required for a significant effect on commercial products. Virginia market-type germplasm (Table 2) has the largest potential resource pool to improve roasted peanut attribute +0.5 flavor units in relation to Florigiant with four germplasm sources. Also the positive estimated difference between control and comparative

Table 2. Comparative variation in the roasted peanut sensory attribute among virginia-type germplasm.

		Roasted Peanut Attribute			
Germplasm	No. Obs.	Mean	Least-square Mean	Dev. from Florigiant	Std. Error*
Florigiant	10	5.4	5.2		
NC 18431	1	6.8	6.6	+1.4	0.61
NC 18423	2	6.2	6.0	+0.8	0.48
NC 18444	1	6.6	6.0	+0.8	0.62
NC 9	1	5.9	5.8	+0.6	0.61
NC 8C	2	6.1	5.6	+0.4	0.46
TRC 05116-J	1	6.1	5.4	+0.2	0.62
UF82107	1	5.9	5.4	+0.2	0.61
NC V11	4	5.2	5.4	+0.2	0.33
VP 8140	1	6.0	5.3	+0.1	0.62
NC 18442	1	6.0	5.3	+0.1	0.62
NC 7	7	5.1	5.2	0.0	0.28
NC 18443	1	5.9	5.2	0.0	0.62
NC 18425	1	5.9	5.2	0.0	0.62
NC 18424	1	5.8	5.1	-0.1	0.62
VNC 851	1	5.8	5.1	-0.1	0.62
NC 18426	1	5.7	5.0	-0.2	0.62
NC 18432	1	5.7	5.0	-0.2	0.62
NC 10C	5	4.7	5.0	-0.2	0.31
72X63-9	1	5.1	4.7	-0.5	0.61
75X3B-6	1	5.0	4.5	-0.7	0.61
UF86106	1	4.9	4.4	-0.8	0.61
NC 18435	1	4.9	4.2	-1.0	0.62
NC 18413	1	4.7	4.0	-1.2	0.62

*Standard error of least-square mean deviation from Florigiant.

Table 3. Comparative variation in the roasted peanut sensory attribute among spanish-type germplasm.

		Roasted Peanut Attribute			
Germplasm	No. Obs.	Mean	Least-square Mean	Dev. from Pronto	Std. Error*
Pronto	6	5.2	4.9		
TxAG-4	1	6.8	6.2	+1.3	0.62
Sn73-33	1	6.7	6.0	+1.1	0.62
TxAG-1	1	6.3	5.6	+0.7	0.62
TxAG-2	1	6.2	5.6	+0.7	0.62
ICGS(E)-46	1	6.1	5.4	+0.5	0.62
Tx771108	1	6.0	5.3	+0.4	0.62
ICGS(E)-56	1	5.9	5.2	+0.3	0.62
Tamnut-74	1	5.9	5.2	+0.3	0.98
Sn 55-437	1	5.8	5.2	+0.3	0.62
TxAG-5	1	5.7	5.1	+0.2	0.62
Starr	2	5.7	5.0	+0.1	0.62
Comet	1	5.2	4.6	-0.3	0.98
Argentine	1	5.0	4.3	-0.6	0.98

*Standard error of least-square mean deviation from Pronto.

germplasm sources was largest within virginia type with an estimated differences of +1.4. Spanish types were next with an estimated difference of +1.3 (Table 3), and runner-type lowest with an estimated difference of +0.5 (Table 4). That runner type has the apparent lowest positive estimated difference and virginia type the largest is of interest since it is generally acknowledged that runner-type peanuts have the highest roasted peanut flavor and virginia types have the lowest roasted peanut flavor. Comparison of the roasted peanut attribute intensities for the two controls, Florigiant and Florunner, is in agreement with this general consensus, since Florunner was +0.9 units higher than Florigiant. Although a difference was shown between the two control cultivars, comparison of the highest roasted peanut attribute levels among this germplasm indicated that both runner and virginia-types have the same potential levels of roasted peanuts attribute. This suggests that virginia-type varieties can be developed which will have the same roasted peanut attribute level as the runner type. Comparison of the spanish-type roasted peanut attribute intensities to both runner and virginia types indicates that the spanish-type germplasm tested does not have an equivalent potential level even though a difference of +1.3 units existed between the control, Pronto, and the highest germplasm source, TxAG-4. Although

Table 4. Comparative variation in the roasted peanut sensory attribute among runner-type germplasm.

		Roasted Peanut Attribute			
Germplasm	No. Obs.	Mean	Least-square Mean	Dev. from Florunner	Std. Error*
Florunner	10	6.3	6.1		
GAT-2524	1	7.2	6.6	+0.5	0.58
Tp107-11	1	7.1	6.5	+0.4	0.53
GAT-2570	1	7.0	6.4	+0.3	0.58
Marc I	1	6.8	6.3	+0.2	0.60
UF81206-1	1	6.7	6.2	+0.1	0.60
GAT-2650	1	6.4	6.2	+0.1	0.59
GAT-2646	2	5.8	6.0	-0.1	0.43
GAT-2566	1	6.6	5.9	-0.2	0.58
GAT-2587	1	6.6	5.9	-0.2	0.58
Langley	5	6.1	5.9	-0.2	0.30
76X4A-3	1	6.4	5.9	-0.2	0.60
GAT-2637	2	6.1	5.9	-0.2	0.45
Okrun	6	5.8	5.8	-0.3	0.29
GAT-2589	1	6.4	5.8	-0.3	0.58
GAT-2641	2	5.5	5.7	-0.4	0.43
GAT-2648	2	5.4	5.6	-0.5	0.43
UF81206-2	1	5.9	5.4	-0.7	0.60
Sunrunner	9	5.2	5.4	-0.7	0.25
GAT-2636	3	5.0	5.4	-0.7	0.37
Tamrun 88	1	6.0	5.3	-0.8	0.61
GAT-2645	2	5.1	5.3	-0.8	0.43
GAT-2590	1	5.9	5.3	-0.8	0.58
Tx833841	1	5.9	5.2	-0.9	0.61
Southern Runner	7	5.3	5.2	-0.9	0.27
GK 7	5	5.0	5.2	-0.9	0.30
GAT-2643	2	5.0	5.1	-1.0	0.43
Sunbelt Runner	4	5.2	5.1	-1.0	0.33
GAT-2642	3	4.7	5.0	-1.1	0.37
GAT-2588	1	5.5	4.9	-1.2	0.58
Tx833829	1	5.1	4.5	-1.6	0.61
Tx835820	1	4.8	4.2	-1.9	0.61
TxAG-3	1	4.0	3.3	-2.8	0.61

*Standard error of least-square mean deviation from Florunner.

a level of roasted peanut attribute comparable to that in runner and virginia-types was not found in this survey, it does not mean that such a source does not exist within the spanish-type germplasm. A difference of +1.3 also suggests that a substantial potential for improvement in roasted peanut attrribute intensity over the present cultivars does exist and efforts towards attaining that improvement could be undertaken.

That an effort must be put forth to maintain high roasted peanut attribute intensity in the cultivars being released for production is evident in the survey of the runner-type germplasm (Table 4). The control, Florunner, is widely recognized as a high intensity roasted peanut flavor source. This survey indicates that only 22% of the tested germplasm sources have a higher roasted peanut attribute level than Florunner. It can further be observed that none of the runner-type cultivars released after Florunner have a higher roasted peanut attribute intensity even though Florunner is a parent for these releases. To maintain the roasted peanut attribute at the current levels attained in the Florunner cultivar, or to be improved upon, a specific effort must be undertaken to evaluate germplasm sources being used in a breeding program for this important attribute.

Heritability of Sensory Attributes

Certain sensory attributes arise as a result of improper handling or processing or chemical contamination, i. e., mold, fruity, stale, overroast, underroast, burnt, petroleum or painty. It has been assumed that certain of the other sensory attributes in roasted peanuts have the potential to be inherited characteristics. However, to the knowledge of the authors, there is no literature available to validate this assumption. Since this study involved a relatively large number of germplasms, tested at a number of locations for several years, it provided an opportunity to examine the question of heritability of sensory attributes in roasted peanuts. A model incorporating random components due to differences between replications within location, among locations within years, among germplasms and residual error was fitted using a restricted maximum likelihood procedure (4). The estimates for the four variance components for the six sensory attributes, which have the potential to be heritable, are given in Table 5. A measure of the relative importance of germplasm source to variation among roasted peanut samples can be obtained by computing the ratio of the component for differences among germplasms to the sum for all components. For roasted peanut attribute this ratio is 0.24, i.e., 24% of the variability in roasted peanut attribute among our samples of roasted peanuts was due to differences in germplasm. A heritability estimate of this magnitude suggests a potential for improving the roasted peanut attribute through breeding and selection.

Table 5. Estimates of variance components for six sensory attributes of roasted peanuts.

Source of Variation	Sensory Attribute					
	Roasted Peanut	Bitter	Sweet	Tongue Burn	Astrin-gent	Nutty
Among rep:	0.00	0.00	0.04	0.00	0.04	0.00
Among loc:	0.02	0.07	0.08	0.01	0.08	0.08
Among germ:	0.10	0.09	0.04	0.02	0.06	0.02
Residual:	0.29	0.34	0.12	0.25	0.27	0.27

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