Interrelationships Between Headspace Volatile Concentration, Selected Seed-Size Categories and Flavor in Large-Seeded Virginia-Type Peanuts[1]

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ABSTRACT

During the 1987 crop year a quality survey using the organic volatile meter (OVM) was conducted at six (A-E) peanut buying stations located throughout Northampton County, NC. Three different frequency distribution patterns were observed for sample headspace volatile concentration (HSVC) levels. At locations A and B about 66% of the samples analyzed had an HSVC of 8.8 mg/kg air or less. An HSVC of 8.8 mg/kg air is considered to be a volatile concentration at which peanut samples are marginally acceptable. Locations C, D, and F had about 58% of the samples with an HSVC of 8.8 mg/kg air or less while Location E had approximately 45%. At an HSVC level of 24.8 mg/kg air or less the percentages were approximately 88, 87, and 69%, respectively. Most of the difference in frequency distribution patterns is thought to result from environmental factors which influenced the average maturity of the crop at harvest. Trained taste panel profiling of a roasted peanut paste made from selected screen-sized seed fractions and HSVC levels indicated that the fruity character note was most characteristic of the off-flavor associated with increasing HSVC values. Low intensity levels were characterized as sweet fruity and higher levels of intensity as an alcohol-fermented fruity character. Further flavor evaluation of roasted peanut paste from selected screen-sized seed fractions showed all fractions with an HSVC of 7.6 mg/kg air or above were unacceptable while fractions with HSVC levels between 5.3 and 3.1 mg/kg air were marginally acceptable. Fractions with HSVC levels at 2 mg/kg air or less were acceptable.

Key Words: *Arachis hypogaea*, groundnut, quality, organic volatile meter, off-flavors, roasted peanut flavor.

Recent development of an organic volatile meter (OVM) (3), which is utilized in the headspace volatile concentration (HSVC) test, has made available a rapid, inexpensive quantitative method for detecting some undesirable flavors in peanuts. Two major quality defects, high-temperature exposure and freeze-damage, are best detected and decisions made on the disposition of defective peanut lots before they are blended with other lots of peanuts. These peanut lots, commonly known as farmers stock lots, are subsampled and graded for marketing at peanut buying stations. The HSVC test was developed to be used as a part of the Federal-State Inspection Service (FSIS) grading procedure. Determination of flavor quality levels as measured by the HSVC test would permit the peanut buyer to make decisions regarding diversion of farmers stock lots from direct edible stocks into non-edible-use-only lots or potential recovery lots. Recovery of diverted peanut lots failing the initital HSVC test could lessen the economic impact of this test on the peanut industry.

This study, during the 1987 crop year, was undertaken to (1) determine the variation in flavor quality, as determined by the HSVC test, which can exist across a county-wide area, (2) determine if sensory notes other than fruity are related to the HSVC test, and (3) determine if a relationship exists between flavor quality, seed size, and HSVC values.

Materials and Methods

Figure 1 shows the proximate location of the six buying stations surveyed within Northampton County, NC during October and November, 1987 and six private weather stations from which rainfall data were obtained. Sample collection commenced on October 12, 1987 except for location F where sample collection started on November 2, 1987 by visiting the designated buying stations and identifying the FSIS check samples to be analyzed. The FSIS check samples used in this study contained approximately 1800 g of peanut fruits and a sample of split-kernels which were used for determination of concealed damage in the original grade sample. The split-kernel sample was co-identified and taken for the HSVC test. The following morning the collected split-kernel samples were analyzed as described by Dickens et al. (3). A maximum of 18 split-kernel samples per day per location were analyzed. Preselected HSVC ranges of <1.8; 1.8 to 2.9; 3.0 to 5.1; 5.2 to 8.7; 8.8 to 14.5; 14.6 to 24.7; 24.8 to 41.7; 41.8 to 69.3; <69.3 mg volatiles/kg air were used for final sample collection purposes. If available, one sample per day per location was randomly selected for collection from each HSVC range from <1.8 up to 24.7. All samples above an HSVC of 24.7 were collected from all sites. Following sample testing a daily sample collection chart was prepared and an afternoon circuit of the buying stations made for final sample collection of designated check samples and collection of appropriate split-kernel samples for next day analysis. This cycle continued until November 6, 1987 or until the buying station closed for the season which ever occurred first. Any sample found to contain freeze-damage was dropped from the study. All collected check samples were stored until Friday of each week when they were transferred to controlled storage at 5 C and 60% R.H. in Raleigh, NC. The collected check samples were combined by location and meter reading range designation and sensory evaluation samples were prepared from these bulked samples. Each bulked sample was shelled and the kernels were screened over a 5.95 mm slotted screen to yield a sound mature kernel(SMK) fraction. The SMK fraction was subdivided, by using slotted screens, into a less than 7.14 mm size seed (U.S. No. 1 grade Virginia-type); 7.14 mm to 9.53 mm size seed; and greater than 9.53 mm size seed. The division at 9.53 mm was dictated by the minimum screen size that would yield the needed sample weight for that fraction.

Headspace volatile concentration was determined on all fractions where sufficient seed weight was available using the prescribed procedure (3). In case of insufficient weight in a fraction the sample was bulked across locations until a sufficient weight was attained for the analysis. All HSVC fractions with an HSVC of <3.0 mg ETOH/kg air were also bulked together because these HSVC ranges have previously been shown to be similar in flavor (6,7).

The 800-g samples of peanuts to be made into roasted peanut paste for sensory and objective color measurements were roasted at 160 C in a Blue M "Power-O-Matic 60" laboratory oven. Roasting time for each seed size fraction was selected by trial roasting and attain-

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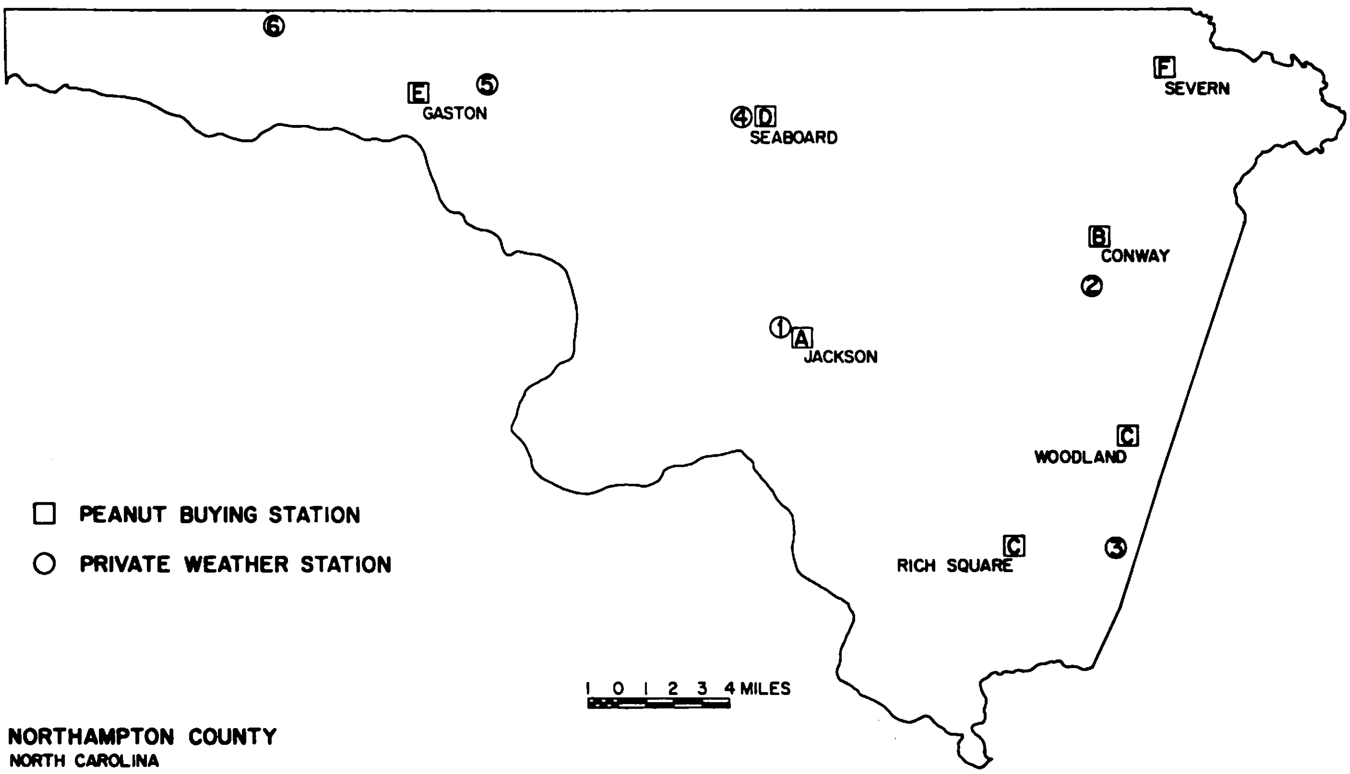

Fig. 1. Northampton County, NC with approximate location of peanut buying stations sampled and location of private weather stations from which rainfall data were collected.

ment of a butter color of about L* = 56. The selected roasting conditions for the three seed size fractions were 12.3 min (<7.14mm), 16.5 min (7.14-9.53mm), and 18.25 min (>9.53mm). Peanuts were ground using an Olde Tyme peanut butter mill, Olde Tyme Food Products Corp., 143 Shaker Road, E. Long Meadow, Mass. 01028. Color measurements were made with a Minolta Chroma Meter II CR-100 on finely ground paste of 100% peanuts (no additives) which had been roasted and blanched. The three color-reflectance parameters, L*, a*, and b*, were read immediately after grinding the peanuts using Falcon No. 1007, 60 x 15 mm, disposable petri dishes as containers.

Sensory evaluation

Peanut butter sensory character notes (Table 1) were evaluated using flavor-by-mouth and aftertaste methods (1,4). Intensities were scored with the fully expanded 14-point scale of Civille and Szczesniak (2) and converted to a 1 to 14 numerical scale (Table 2) for statistical treatment of the data. A 9-member peanut flavor panel which has been functioning for 15 years was used (5), with never less than 6-members for any given session. Within the initial session the panelists were given an orientation session using a peanut paste reference sample and extremes of the experimental samples. To minimize panelist fatigue a limited sensory character note ballot was developed using input from the panelist during the orientation session. The panel met twice weekly between 9 AM and 12 Noon and evaluated six samples per session. A peanut paste reference sample was presented at each session. The statistical design of presentation was a 3 X 3 Latin Square with duplicate samples, thus providing a within and between panel session variance term. The two 3-level factors evaluated were HSVC < 3.0 mg/kg air, 8.8-14.5 mg/kg air, and > 69.3 mg/kg air and seed size, 5.95-7.14 mm, 7.14-9.54 mm, > 9.54 mm. Consensus values were obtained on the sensory character notes and the panelists were asked to give an overall impression rating of the samples. A statistical study of peanut butter flavor scores by this panel (13) showed only a 4% average difference in the cumulative proportion of variance accounted for between mean and consensus scores thus documenting that the use of consensus scores from this trained peanut flavor panel is valid. The consensus data were subjected to a statistical analysis of variance (11).

Table 1. Sensory perception methods used and definition of sensory character notes evaluated.

Sensory Perception Methods:	
Flavor-by-Mouth	- Keeping sample covered as much as possible, place in mouth amount of sample necessary to taste and evaluate the intensities in each sensory character note.
Aftertaste	- Swallow or remove sample from the mouth and evaluate the sensory character notes and their intensities that remained or occurred for approximately 1 minute.
Definition of Sensory Character Notes:	
Roasted Peanut	- Degree of roasted peanut- a buttery, nutty flavor or aroma
Overroast	- Flavor and aroma of overroasted peanut from barely overroasted to charred
Underroast	- Aroma or flavor of raw peanut
Fruity	- Aroma or flavor of fruit, further characterized by fermentation or sweet aromatic
Bitter	- The basic taste
Sweet	- Degree of natural sweetness perceived
Nutty	- The nut-like flavor that remains after swallowing the sample
Throat/Tongue Burn	- Degree to which a burning sensation is felt in the throat and tongue

Table 2. Definition of numeric sensory character scores.

Numeric Value	Definition
1	Not detectable
2	Threshold, barely detectable
3	
4	Barely detectable to slight
5	
6	Slight
7	
8	Slight to moderate
9	
10	Moderate
11	
12	Moderate to strong
13	
14	Strong

Results and Discussions

General Market Quality and Environmental Considerations

The mean values for selected quality variables provide indications as to the general quality of the crop being marketed at each of the six locations (Table 3). The sound mature kernel + sound splits (SMK+SS) values, when less than 68 for large-seeded virginia-type peanuts, suggest that the overall maturity level of the crop was lower than desirable (8,9). Locations D, E, and F were sources of the most immature peanuts. Immature peanuts have a lower roasted flavor potential (10), are more susceptible to freeze damage (12) and more susceptible to high temperature exposure off-flavor (14), whether it be while curing in the windrow or in a drying wagon. At Location E where there is the greatest evidence for immaturity in the crop we can also note that there is a higher mean and maximum HSVC in the peanuts (Table 3). Rainfall distribution throughout Northampton County (Table 4) is in general agreement with the maturity level changes and provides some insight as to the possible cause of the maturity differences since inadequate soil moisture retards maturity progression. The extremely low rainfall in the western part of the county (Gaston, west) is of particular interest because the peanuts from that area were marketed at Location E and the data differences obtained at Location E. Peanuts from Location 5 were not necessarily marketed at Location E because an intersecting Interstate highway prevents ready access to Location E.

Table 3. Mean and maximum values for selected quality variables of farmers stock peanuts marketed at six locations in Northampton County, North Carolina.

Quality Variables	Locations A	B	C	D	E	F
			Means			
HSVC[1/]	9.3	10.6	14.9	12.9	27.2	14.8
SMK+SS[2/]	64.2	64.5	65.8	61.8	61.4	62.8
OK[3/]	4.2	4.4	3.6	5.3	5.4	5.1
			Maximums			
HSVC	48.8	67.7	91.0	130.2	221.4	69.5

Comparison Significant Differences for Means p<.05=*; p<.01=**

	HSVC					SMK+SS					OK				
Locations	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
B	NS	.				NS	.				NS	.			
C	*	NS				**	**				**	**			
D	NS	NS	NS	.		**	**	**	.		**	**	**	.	
E	**	**	**	**		**	**	**	NS	.	**	**	**	NS	.
F	NS	NS	NS	NS	NS	NS	NS	**	NS	NS	**	*	**	NS	NS

	A	B	C	D	E	F
No. of Observ.	230	101	71	135	162	23

[1/]HSVC is the abbreviation for Headspace Volatile Concentration (mg/kg air).

[2/]SMK+SS is the abbreviation for Sound Mature Kernels plus Sound Splits.

[3/]OK is the abbreviation for Other Kernels.

Table 4. Rainfall data for July, August, and September, 1987 from six private weather stations located within Northampton County.

Location	Months (1987) July	August	September
		Rainfall (cm)	
Jackson, NC (1)	13.66	9.04	14.45
Conway, NC (2)	9.40	7.11	12.27
Rich Square, (3)	4.06	11.38	19.61
Seaboard, (4)	5.59	8.13	16.00
Gaston, east (5)	11.68	7.62	16.51
Gaston, west (6)	6.35	3.05	n/a

Distribution of Headspace Volatile Concentration Values by Locations

The differences in mean and maximum values of HSVC for the individual locations (Table 3) suggest a difference in the distribution of HSVC values within a location. To determine if individual locations had similar distribution patterns a Chi-Square test was performed on selected location combinations (Table 5). Based on the significant differences in the Chi-Square values the distribution in HSVC values for Location E (combination 1) is significantly different from the other locations. Separating Locations A and B together from Locations C, D, and F, together and from Location E (combination 2) also gives a significant Chi-Square value and the difference between the Chi-Square values for combination 1 and combination 2 is also significantly different thus the combined locations A and B; CFD; and E have significantly different distribution of HSVC values. Separating Location C as an independent location does not produce a significant improvement thus indicating that there are three general distribution patterns within the data. The three general distribution patterns found in this study are shown in Fig. 2. The HSVC distribution pattern for locations A and B is most typical of HSVC distribution patterns for previous observations taken in North Carolina, Georgia, and Texas (6,7). In the previous studies approximately 80% of the samples analyzed had an HSVC value of less than 8.8 and 95% were less than 24.8 while in this study we found the percentages to be 66% and 88% at the same HSVC for the combined Locations A and B.

Table 5. Chi-Square values for selected location combinations across the same distribution levels.

Selected Location Combination	df	Chi-Square Value
Combination 1 ABCDEF vs E	8	46.2**
Combination 2 AB vs CDF vs E	16	65.1**
Combination 1 vs 2	8	18.9*
Combination 3 AB vs C vs DF vs E	24	71.8**
Combination 2 vs 3	8	6.7ns

*,**Significant at the 0.05 and 0.01 probability levels, respectively.

nsNon-significant

Headspace Volatile Concentration Test and Flavor Relationships

To establish which sensory character note best describes high temperature exposure off-flavor roasted peanut paste samples with varying degrees of high tem-

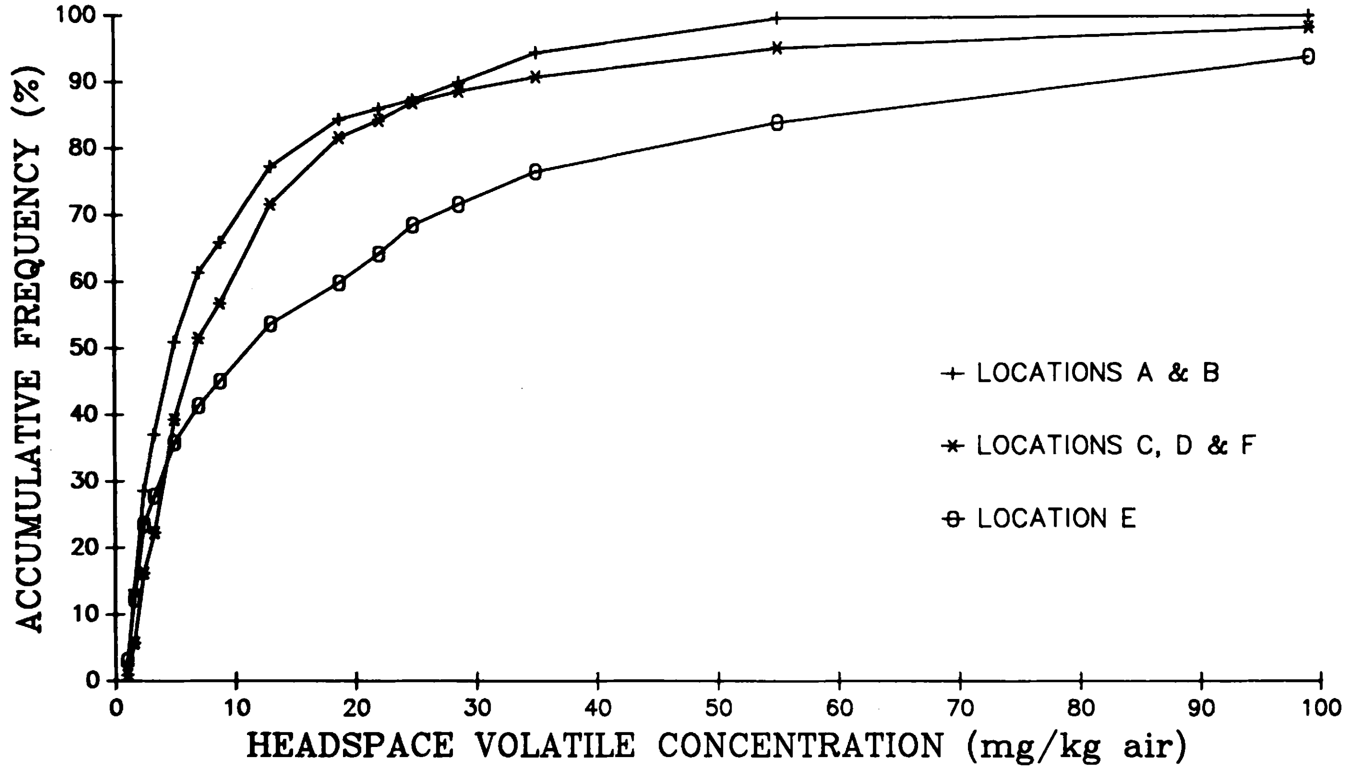

Fig. 2. Accumulative frequency distribution of headspace volatile concentration values for three peanut buying station location combinations.

perature exposure off-flavor were presented to the peanut flavor panel for full sensory character profiling. The sensory character selected by the flavor panel to characterize high temperature exposure off-flavor was 'fruity'. To further characterize this sensory character the panel indicated that at low intensity levels, i.e. up to 4, the sensory character is a sweet fruity. Above level 4 the sensory character increases as an alcoholic, fermented fruity.

Previous reports (6,7) have indicated a relationship between the intensity of high temperature exposure off-flavor and the meter reading of the HSVC test. However, it is not always possible to make a direct comparison of meter readings from different meters thus equations to convert meter readings to HSVC values, which permit comparisons between HSVC tests, have now been published (3). The relationships found between HSVC values and fruity flavor intensity of the samples evaluated in this study (Table 6) are the same as have been previously reported (6,7). When the HSVC value is less than 3 mg volatiles/kg air the fruity flavor intensity is between not detectable and barely detectable (Table 2) and the roasted flavor intensity is above 7 which is higher than normal for large-seeded virginia type peanuts (Pattee, 1986, unpublished data). We considered these samples highly acceptable based on overall impression. For HSVC values of 3.1 and 5.3 mg volatiles/kg air the fruity response intensity was rated as slight and the roasted flavor intensity was reduced nearly a full unit. We considered these samples to be barely acceptable for use. The sample representing HSVC range R and seed size 5.95-7.14 mm has a low flavor balance and is considered to be unacceptable. The data point out the difficulty in producing a high quality product from U.S. No. 1 grade peanuts. Three additional categories were considered to be unacceptable; HSVC range V - seed size 5.95-7.14 mm, HSVC range Z - seed sizes 5.95-7.14 and 7.14-9.54 mm. In all three HSVC groups the smallest seed size range has the highest HSVC levels. This observation emphasizes the sensitivity of immature peanuts to optimum conditions to maintain quality and the rapid deterioration in quality which occurs in immature peanuts when less than optimum production and curing conditions are encountered.

Table 6. Interrelationships between headspace volatile concentration, fruity flavor, roasted peanut flavor and selected seed size ranges.

HSVC[4/] Range	Headspace Volatile Concentration (mg/kg Air)	Flavor Characteristic	Selected Seed Size Range 5.95-7.14	7.14-9.54	> 9.54mm
R[1/]	HSVC[4/]		7.6	1.4	1.5
			Mean Characteristic Intensity		
		Fruity	7.5	1.5	1.2
		Roasted Peanut	4.9	7.1	7.1
V[2/]	HSVC		18.7	3.1	2.0
		Fruity	10.9	4.8	1.4
		Roasted Peanut	2.3	6.5	7.5
Z[3/]	HSVC		79.9	28.6	5.3
		Fruity	11.6	10.9	4.6
		Roasted Peanut	1.8	2.4	6.1

Least Significant Difference - Fruity 2.7, Roasted Peanut 1.2.

1/ Federal-State Inspection Samples with HSVC < 3.0 mg/kg air.
2/ Federal-State Inspection Samples with HSVC 8.8-14.5 mg/kg air.
3/ Federal-State Inspection Samples with HSVC > 69.3 mg/kg air.
4/ HSVC is the abbreviation for Headspace Volatile Concentration (mg/kg air).

Comparison of fruity and roasted peanut intensity levels (Table 6) points out the negative effect that increasing intensity of the fruity character has on the perceived intensity of the roasted peanut flavor character. The absence or threshold level of the fruity character permits full expression of the roasted peanut flavor character (HSVC range R - seed size > 7.94). An intensity of 4 to 5 for fruity suppressed the perceived roasted peanut character by about one numerical intensity level (HSVC range Z - seed size > 9.54 mm) while a 10 to 11 fruity intensity suppresses the perceived roasted peanut intensity two to three numerical levels. These intensity levels almost completely eliminate the perception of the roasted peanut character (HSVC range R vs. Z - seed size 7.14-9.54 mm). Thus from a quality standpoint the presence of the fruity character not only gives an off-flavor perception but also diminishes the typical roasted peanut character.

Summary

This survey of the 1987 peanut crop in Northampton County, NC using the HSVC test has not only provided confirmatory results to previous HSVC tests (6,7) but has provided new insights as to the distribution of HSVC levels at different peanut buying stations and distribution of HSVC levels across given seed size ranges within a farmers stock peanut lot. When detrimental conditions occur, as around location E, the quality of the crop is severely impaired as evidenced by only 69% of the crop having an HSVC level of less than 24.8 mg volatiles/kg air. The available grade data suggests that immaturity of the crop is the underlying reason for this quality impairment. The data presented further support the concept that immature peanuts are more susceptible to quality impairment in that all U. S. No. 1 fractions analyzed in this study were found to have unacceptable product potential.

The presence of the fruity character in sensory evaluation of roasted peanuts has long been recognized as an off-flavor. However, the impact of the fruity character in suppressing the perceived roasted peanut flavor character had not been previously documented. The data presented suggest that for each two unit numerical increase in fruity character intensity there is about a one unit numerical decrease in perceived roasted peanut flavor intensity. Such an impact highlights the need to minimize the presence of the fruity character in all peanut products to maximize the desirable roasted peanut character. The results support the suggestion that HSVC test can be used to detect the presence of the fruity off-flavor character in peanut lots.

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