Interaction of Curing Temperature and Inherent Maturity Distributions on Descriptive Flavor of Commercial Grade Sizes of Florunner Peanuts[1]

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ABSTRACT

Windrow-dried Florunner peanuts were harvested and then cured with ambient air (maximum 35 C), ambient +8.4 C increase, and ambient +16.8 C increase in commercial drying operations. Peanuts from the drying wagons were stored inshell as farmers stock or shelled and then cold stored approximately five months before sensory evaluation. A panel trained in peanut flavor descriptive analysis evaluated peanuts from all commercial grade sizes which had been roasted to similar color. Differences between cold- and farmers stock-stored peanuts were not statistically significant and data were thus combined. Curing treatments produced differences in descriptive terms roasted peanutty, fruity fermented and sour. Fruity fermented intensity was noticeably higher in the medium and No. 1 grade sizes from the higher curing temperatures and roasted peanutty decreased in the No. 1 grade with increasing temperature. Significant differences in intensity of seven descriptors were consistently found among the grades within each curing treatment. For each of these descriptors as size decreased, intensity of desirable flavor descriptors decreased and intensity of off-flavor descriptors increased.

Key Words: *Arachis hypogaea*, sensory evaluation, roasted peanuts, peanut drying, peanut flavor

High temperature curing off-flavor has been recognized as a significant potential problem in the bulk handling practices of peanuts for over 30 years (1, 3, 4). Temperatures above 35-38 C have been consistently associated with off-flavors, especially in immature peanuts (4, 10). In studies on high temperature curing, Whitaker and Dickens (26) demonstrated the role of anaerobic respiration in development of more off-flavor in immature vs mature peanuts based on evaluations of raw peanuts. In that study (26) maturity was determined by internal hull color and size considerations were not discussed. In practice, the term immature has usually been associated with small peanuts (10). Although this practice was not an incorrect assessment, several researchers have demonstrated that a wide range of peanut sizes may be obtained from various maturity classifications (17, 18, 29) and, thus, specific grade sizes contain peanuts of various maturities (18). Sanders *et al.* (19, 20, 21) demonstrated that immaturity, apart from size considerations, was in fact related to off-flavor development when medium grade size peanuts from immature Hull Scrape (28) maturity classes were found after curing to have less roasted on-flavor and more off-flavor than mature classes after curing.

Singleton *et al.* (23) evaluated the effect of curing temperature on raw peanut flavor and found distinct preference for peanuts cured at lower temperatures. Holaday *et al.* (6) and Matlock (10) reported higher CLER scores for peanuts cured at lower temperatures.

Descriptive flavor analysis is a relatively new method of assessing flavor in peanuts. Oupadissakoon and Young (12) and How (7) utilized descriptive flavor terminology to define the effects of variety, roasting, and storage of packaged peanuts. Johnson *et al.* (8) developed a lexicon of descriptive flavor terms that were utilized and enlarged by Sanders *et al.* (19, 21) to describe effects of maturity and curing temperatures on peanuts of different maturity but of the same size. Pattee *et al.* (15, 16) utilized descriptive flavor analysis to evaluate interrelationships of headspace volatile concentration, seed size, and flavor in virginia- and runner-type peanuts.

The objective of this study was to determine the effects of three curing treatments on descriptive flavor of commercial grade sized roasted peanuts. Intensities of flavor descriptors were determined on peanuts which were shelled after curing and placed in cold storage and peanuts which were placed in farmers stock storage and then shelled to obtain commercial sizes.

Materials and Methods

Peanuts (*Arachis hypogaea* L. cv Florunner) used in these studies were obtained from a field in which the Hull Scrape maturity method (28) indicated 0-3 days until harvest. Peanuts were dug 142 days after planting and irrigation had been utilized to insure adequate moisture. Peanuts were dried in windrows for 3 days with variable but generally good drying conditions to approximately 26% moisture. Combine operations were initiated in the middle of the field and conducted to obtain three uniform loads of peanuts (approximately 4082 kg each). Drying wagons were attached to Peerless model 153J dryers which were used to provide curing treatments of ambient air, 8.4 C rise above ambient (+8.4 C) and 16.8 C rise ambient (+16.8 C). The dryers were fitted with properly sized burner orifices to provide the required temperature increase. Type T thermocouples were used to measure temperatures of ambient air, air entering the wagon plenum and temperatures approximately 20 cm below the surface of the load. Data were collected automatically at 15 min intervals with a Monitor Labs model 9302 data logger. Artificial curing (heated air application) was terminated when the moisture content of peanuts on each wagon was reduced to approximately 10%.

Maturity distributions were determined from ca. 45 kg of peanuts collected after combining. The peanuts were classified into Hull Scrape maturity classes (28), dried (ca. 8%), shelled, sized, and weighed before the percentage of each class in each size was calculated (18).

When wagons were dumped for warehouse storage, twelve 23-kg burlap bags of peanuts were randomly cut from the flow of peanuts. Six bags were randomly selected and the peanuts were shelled, sized, and placed in cold storage (1.7 C) during approximately the same time period as peanuts which were warehouse stored. Six of the 23 kg bags were randomly selected, transferred to mesh bags, and placed in farmers stock storage approximately 1 m below the surface of peanuts in the warehouse. Peanuts were placed in warehouse storage on September 23, 1986 and removed on February 3, 1987. Mean temperature and relative humidity near the bages were ca. 17 C and 70%, respectively, during warehouse storage. Peanuts removed from warehouse storage were shelled, sized, and placed in cold storage (1.7 C) approximately 30 days before roasting.

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The designation and seed thickness requirements for the runner-type commercial grade sizes used for descriptive flavor analysis were jumbo ≥ 8.3 mm > medium ≥ 7.14 mm > No. 1 ≥ 6.35 mm > other edible ≥ 5.56 mm (25). Samples shelled soon after curing and farmers stock warehouse stored peanuts were roasted during the same time period. All samples were adjusted to 5.5±0.5% moisture with ambient air and roasted using a standard protocol (21) in a modified Farberware roaster, model 355 (5). Within a grade size, samples were roasted for the same time. Initial and final roaster temperatures were approximately 36.6±1.5 C and 176.0±5.0 C, respectively. Peanuts were blanched with a laboratory blancher (2) and color was then determined with a HunterLab colorimeter.

Paste was made from roasted peanuts in a Cuisinart food processor using a precise grind-cool protocol to maintain temperature below 32 C. Peanut paste color was determined and samples were immediately frozen until sensory analysis. Pastes were presented to a 12-member panel trained in the Spectrum Flavor Descriptive Analysis technique (11) to fully characterize the qualitative and quantitative aspects of peanut flavor. Each panelist evaluated the samples independently under red lights. Samples were presented randomly in white transparent cups with three digit random numbers. Samples of each commercial grade size were assigned intensity ratings (0-15) for descriptive terms described by Johnson *et al.* (8) and Sanders *et al.* (21). Peanut paste samples were presented under the assumption of no significant session effect. To monitor session effect, a blind control peanut paste was presented at each session, along with eight experimental samples. No significant difference in blind control mean intensities between sessions occurred. All data are the means of at least 3 panel presentations. Data were analyzed using a Statistical Analysis System (22) program package. The analysis of variance (ANOVA) was performed as a factorial design and significant differences among means were determined by the Waller Duncan Test.

Duplicate volatile analyses of raw grade sized peanuts from each treatment were performed by gas liquid chromatography using columns packed with Tenax GC 80/100 mesh coated with 8% PMPE as previously described (9). Ethanol concentrations alone are reported as indicators of curing treatments effects.

Results and Discussion

Wagon plenum air temperatures for each curing treatment are shown in Fig. 1. Artificial curing (heated air application) was terminated after 21.5 hrs, 35.75 hrs and 108.75 hrs when peanut moisture contents were 10.86%, 10.44% and 9.42% for the +16.8 C, + 8.4 C and ambient air treatments, respectively. Maximum plenum air temperatures of 50.9 C, 42.6 C and 33.4 C were attained approximately 13 hrs after curing began. Temperature maxima of peanuts 20 cm below the surface of the load were ca. 3 C lower than plenum air temperatures (19).

The work of Dickens (4), Whitaker and coworkers (26, 27), Pattee *et al.* (13), and Singleton *et al.* (23) collectively demonstrated that ethanol concentrations increase with increasing curing temperature and that smaller peanuts should contain highest concentrations. Ethanol

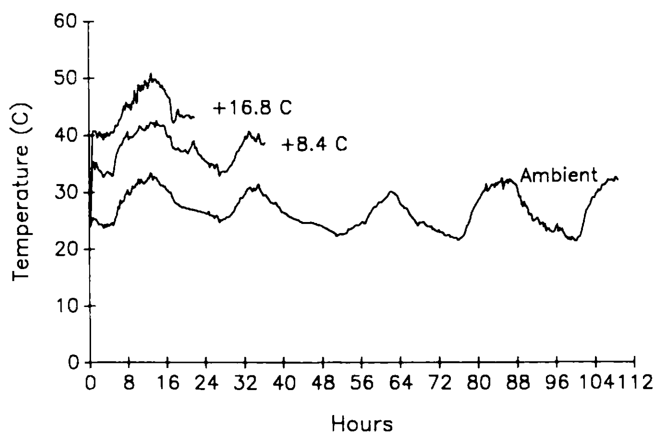

Fig. 1. Wagon plenum air temperatures for ambient air, ambient air +8.4 C and ambient air +16.4 C curing treatments.

concentrations found in various peanut grade sizes from the three curing treatments indicate the progressive treatment effects of increasing curing temperature on various grade sizes (Table 1). Relationships of specific volatiles, including ethanol, to flavor descriptor intensities are outside the planned scope of this manuscript and are the intended subject of a subsequent manuscript.

Table 1. Ethanol Concentration of Commercial Grade Size Peanuts from Three Curing Treatments.

Grade Size	Curing Treatment		
	Ambient	Ambient +8.4 C	Ambient +16.8 C
	Ethanol (ppm)		
Jumbo	1.77	2.01	5.03
Medium	1.97	2.57	7.35
Number 1	2.96	5.53	20.23
Other Edible	4.14	7.29	26.11

Hunter L values for the peanut pastes used for sensory analysis are shown in Table 2. Paste colors within a grade size were very similar; however, the OE grades were roasted to an overall lighter color as a precaution against overroasting the small size seed. Small increases in time cause large increases in degree of roast within this grade size. The paste color differences of the OE grade compared with other grades were twice as large as the color differences of peanuts from those grades immediately following roasting and blanching. Possibly small pieces of seed coat remaining on the OE peanuts after blanching produced a lower L value and gave an incorrect evaluation of degree of roast. Differences in paste color suggest that numerical values determined for OE sensory descriptors may be under- or overestimations, depending on the specific descriptor. However, such a suggestion is based on the unproven idea that roasting all grade sizes to the same Hunter L value produces the optimum roast flavor profile for each. Thus the comparisons of OE data to other grade sizes must be evaluated accordingly. However, because of the limited number of descriptor intensities found significantly different in maturity studies (21) which included differences up to 4 Hunter L units and data presented by Pattee *et al.* (14) demonstrating that a Hunter L difference of 5 did not affect flavor scores of 5.95 mm (L values 44.4 and 49.3) and 8.74 mm (L values 49.1 and 54.3) size seed, we suggest that although OE numerical data may be slightly skewed toward underroast, the statistical trends determined are verified by previously published information.

Maturity distributions (percentage of each maturity class in a grade size) for grade sizes in these tests demonstrate an increase in the percentage of immature peanuts as size of peanuts decrease (Table 3) (18). The effect of this inherent distribution is evident in the ethanol values in Table 1. As demonstrated by Whitaker and Dickens (26) in measuring anaerobic respiration, the other edible size is most affected not because of size but because of the high percentage of immature peanuts. Likewise, the immature peanuts in each grade size were more affected by high temperature curing (19). The flavor profile of grade sizes, a composite of all maturity stages in a grade, is discussed in the following paragraphs.

Samples stored in the farmers stock warehouse and those shelled and stored at 1.7 C had only minor variation in descriptive flavor profile. Pattee *et al.* (14) and Smith *et al.*

Table 2. Peanut Paste Colors of Commercial Grade Size Peanuts from Three Curing Treatments.

Treatment	Grade Size			
	Jumbo	Medium	Number 1	Other Edible
	Hunter L Value			
Cold Stored				
Ambient	50.7	50.0	49.8	56.3
A+8.4 C	51.2	51.9	51.9	55.4
A+16.8 C	51.7	51.8	51.7	55.4
Warehouse				
Ambient	50.2	49.6	50.6	55.3
A+8.4 C	51.4	50.4	51.6	56.4
A+16.8 C	51.8	50.2	51.1	54.2

Table 3. Maturity Distribution in Commercial Grade Size Florunner Peanuts.

Maturity Class	Grade Size			
	Jumbo	Medium	Number 1	Other Edible
	Percent Weight			
Yellow 2	4.7	13.4	48.6	63.0
Orange A	5.4	9.9	17.4	18.5
Orange B	11.6	14.4	15.4	14.6
Brown	32.3	27.9	11.7	3.2
Black	46.0	34.4	6.9	0.7
Total	100.0	100.0	100.0	100.0

(24) have previously reported that changes in flavor are minor in limited duration cold storage and farmers stock storage. Data from all samples were combined for further analysis. Results of the analysis of variance on the total data set indicated that the main effects were significant for many of the flavor descriptors and that the interaction of seed size and curing treatment was significant only for the descriptors sour and fruity fermented (Table 4).

Table 4. Results of ANOVA on Total Sensory Descriptor Data of Peanuts from Three Curing Treatments.

Descriptors	Size	Curing Trt	Size/Curing Trt
Roasted Peanutty	**	**	
Raw/Beany	**		
Dark Roast	**		
Sweet Aromatic		**	
Woody/Hulls/Skins			
Cardboard			
Painty	**	**	
Fermented/Fruity	**	**	*
Sweet	**		
Sour	**	**	**
Bitter			
Salty	*		
Astringent		**	

*,** Significant at the 0.05 or 0.01 level, respectively.

This study provided data to compare descriptive flavor intensity ratings of peanuts of the same grade size from three curing treatments. The data were also used to compare the descriptive flavor of different grade size peanuts within each curing treatment. Since more differences were found in the grade size comparisons within curing treatments, data for all descriptors are presented in that format while an abbreviated list of descriptors (Table 5) has been used for the curing treatment comparisons. For comparisons within each treatment, the effect of curing temperature on descriptor intensity was examined on four peanut grade sizes although there were interactions only as previously indicated.

Table 5. Flavor Descriptor Intensity Ratings for Peanuts of the Same Commercial Grade Size from Three Curing Treatments.

Grade Size	Descriptors	Curing Treatment		
		Ambient	+ 8.4 C	+ 16.8 C
Jumbo	Roasted Peanutty	5.77 a	5.86 a	5.79 a
	Fruity Fermented	0.24 a	0.24 a	0.10 a
	Sour	0.83 a	0.88 a	0.79 a
Medium	Roasted Peanutty	5.59 a	5.76 a	5.53 a
	Fruity Fermented	0.19 b	0.57 ab	0.89 a
	Sour	0.83 a	0.90 a	1.09 a
Number 1	Roasted Peanutty	5.29 a	5.33 a	4.28 b
	Fruity Fermented	1.35 b	1.54 b	2.94 a
	Sour	1.10 b	1.20 b	2.04 a
Other Edible	Roasted Peanutty	3.79 a	3.65 a	3.46 a
	Raw Beany	4.10 a	4.38 a	3.40 b
	Fruity Fermented	3.20 ab	2.54 b	3.73 a
	Sour	1.50 b	1.79 ab	2.08 a

Within each size, descriptor intensities followed by different letters were significantly different. Table includes all descriptors in which differences significant at $p \leq 0.05$ were found.

Roasted peanutty intensity differences among curing treatments were not found to be significantly different except in the No. 1 grade size (Table 5). In a companion study conducted under the same drying conditions, we reported that the number of maturity classes with significantly lower roasted peanutty intensity increased with increasing curing temperature (19). At +8.4 C, the yellow 2 maturity class was lower in roasted peanutty intensity and at +16.8 C both yellow 2 and orange A classes were lower. The study was conducted using only medium grade size peanuts from each maturity class to reduce the size effects on roasting parameters. Progressively smaller grade sizes contain higher percentages of immature peanuts (18); thus, the appearance of reduced roasted peanutty in the No. 1 grade relates to the fact that immature peanuts have inherently less potential for high roasted peanutty intensity and this potential is reduced by high curing temperatures (19). The fact that no significant differences were found for roasted peanutty among the other edible grade sizes may relate to the low intensities found across all curing treatments which may be due in part to the low degree of roast.

Because peanuts in a sized lot are composed of various percentages of maturity classes (maturity distributions) (18), the sized lot exhibits flavor characteristics based on the flavor and quantity (percentages) of the various maturity classes. This concept is evident in the medium grade in Table 5 where the first indication (large size to small size) of off-flavor in the form of fruity fermented was evident. In the companion study previously mentioned (19), we found that peanuts of the same size from different maturity classes responded differently to curing temperature. At +16.8 C fruity fermented intensity was approximately three times higher in the two most immature classes than in the other three classes. Because the curing treatments and peanut lots were exactly the same, it appears that the significantly higher intensity of fruity fermented in the medium grade (+16.8 C) in Table 5 arose from the flavor in yellow 2 and orange A seed in the medium grade size (Table 3). Intensity for fruity fermented in yellow 2 and orange A seed was lower in the 8.4 C treatment (19) resulting in an overall lower intensity in the medium 8.4 C peanuts (Table 5). Thus the percentage of seed and intensity of various flavor descriptors of the individual maturity classes found in the medium grade size of each treatment formed the basis for the observed flavor differences.

In 1987, Sanders *et al.* (20) reported decreases in roasted peanutty intensity concomitant with increases in fruity fermented intensity in medium sized peanuts of various maturity stages which had been improperly cured. Sanders *et al.* (19) using maturity stages cured at different temperatures and Pattee *et al.* (15) using sized peanuts with increasing headspace volatile concentrations demonstrated the role of high temperature curing in the inverse relationship of roasted peanutty and fruity fermented intensities. Sanders *et al* (19) found little flavor descriptor change in black, brown, and orange B maturity classes which normally comprise the greatest percentage of jumbo and medium grade sizes (Table 3). Pattee et al (15) reported lower headspace volatile concentrations for large peanuts than for small peanuts and the ratio of roasted peanutty to fruity fermented intensity was larger for large seed than for small seed. The data in Table 5, except for the lack of decrease in roasted peanutty in OE, compare favorably to the maturity and size trends reported previously by Sanders *et al.* (19) and Pattee *et al.* (15). Differences in the degree of sensory change in this report and studies by Pattee *et al.* (15) and Yokoyama *et al.* (30) are possibly related to the severity of damage imparted during curing.

Immature peanuts have been shown to have many more reactive and less stable components (oil composition, amino acid and protein composition, enzymes, moisture) and to possess less potential for high flavor and more potential for off-flavor (19, 21). The fact that maturity and size are related is certainly not new; however, understanding and demonstration of the descriptive flavor differences in commercial grade sizes is limited in currently available literature. In general as seed size increases, off-flavor potential decreases, and desirable flavor potential increases largely due to the maturity distribution previously discussed. In all three curing temperature treatments the type of descriptive flavor differences among grade sizes were similar; however, the magnitude of difference was increased in the +16.8 C treatment (Tables 6-8). Significant differences in intensity of several descriptors were consistently found among the grade sizes in each curing treatment. For each of these descriptors as size decreased, intensity of desirable flavor descriptors decreased, and intensity of off-flavor descriptors increased. Differences in intensity of descriptors between jumbo and medium grade peanuts were significant only for fruity fermented in the +16.8 C treatment. Differences between jumbo/medium and the No. 1 grade were present even in the most gentle curing treatment, ambient air. The differences between No. 1 and other edible grade were generally greater than those with the jumbo/medium. These differences relate well to the type differences reported previously for maturity classes (21) and substantiate further the relationship of size to maturity and the effect of maturity distributions in sized peanut lots.

Table 6. Flavor Intensity Scores of Commercial Grade Size Peanuts Cured at Ambient Temperature.

Descriptors	Grade Size			
	Jumbo	Medium	Number 1	Other Edible
Roasted Peanutty	5.78 a	5.59 a	5.29 a	3.79 b
Raw/Beany	2.14 c	1.99 c	3.02 b	4.10 a
Dark Roast	3.55 a	3.68 a	2.58 b	1.73 c
Sweet Aromatic	3.37 a	3.19 a	3.44 a	3.65 a
Woody/Hulls/Skins	2.40 a	2.50 a	2.34 a	2.29 a
Cardboard	0.57 a	0.73 a	0.72 a	0.59 a
Painty	0.02 b	0.17 ab	0.19 ab	0.43 a
Fermented/Fruity	0.24 c	0.19 c	1.35 b	3.20 a
Sweet	2.17 bc	2.04 c	2.48 b	2.91 a
Sour	0.83 b	0.83 b	1.10 b	1.50 a
Bitter	2.32 a	2.29 a	1.90 a	1.73 a
Salty	0.72 a	0.72 a	0.72 a	0.65 a
Astringent	2.56 a	2.52 a	2.43 a	2.33 a

For each descriptor, intensities followed by the same letter are not significantly different ($p \leq 0.05$).

Table 7. Flavor Intensity Scores of Commercial Grade Size Peanuts Cured at Ambient +8.4 C.

Descriptors	Grade Size			
	Jumbo	Medium	Number 1	Other Edible
Roasted Peanutty	5.87 a	5.76 a	5.33 a	3.85 b
Raw/Beany	2.02 c	2.20 c	2.75 b	4.36 a
Dark Roast	3.20 a	3.29 a	2.60 b	1.67 c
Sweet Aromatic	3.14 a	3.30 a	3.41 a	3.20 a
Woody/Hulls/Skins	2.16 a	2.19 a	2.30 a	2.05 a
Cardboard	0.66 a	0.63 a	0.64 a	0.74 a
Painty	0.09 b	0.07 b	0.30 ab	0.52 a
Fermented/Fruity	0.24 c	0.57 c	1.54 b	2.54 a
Sweet	2.19 b	2.12 b	2.54 ab	2.82 a
Sour	0.88 b	0.90 b	1.20 b	1.79 a
Bitter	2.16 a	2.13 a	1.91 a	1.97 a
Salty	0.76 a	0.76 a	0.77 a	0.63 b
Astringent	2.52 a	2.67 a	2.70 a	2.43 a

For each descriptor, intensities followed by the same letter are not significantly different ($p \leq 0.05$).

Table 8. Flavor Intensity Scores of Commercial Grade Size Peanuts Cured at Ambient + 16.8 C.

Descriptors	Grade Size			
	Jumbo	Medium	Number 1	Other Edible
Roasted Peanutty	5.79 a	5.53 a	4.28 b	3.46 a
Raw/Beany	2.01 b	2.12 b	2.94 a	3.40 a
Dark Roast	3.32 a	3.25 a	2.49 b	1.84 a
Sweet Aromatic	3.13 a	3.14 a	3.10 a	3.09 a
Woody/Hulls/Skins	1.94 a	2.25 a	2.33 a	2.13 a
Cardboard	0.57 a	0.75 a	1.03 a	1.07 a
Painty	0.15 b	0.15 b	0.50 ab	0.90 a
Fermented/Fruity	0.10 d	0.89 c	2.94 b	3.73 a
Sweet	2.00 b	2.04 b	2.46 b	2.97 a
Sour	0.79 b	1.09 b	2.04 a	2.08 a
Bitter	2.00 a	2.50 a	2.19 a	2.37 a
Salty	0.72 a	0.78 a	0.82 a	0.75 a
Astringent	2.67 a	2.94 a	2.65 a	2.65 a

For each descriptor, intensities followed by the same letter are not significantly different ($p \leq 0.05$).

Summary

Sized lots of peanuts have potential for descriptive flavor differences due to the differential effects of curing treatments on peanuts of different maturity and the maturity distributions found in sized lots. Additionally, other deviations from normal growth and harvest, such as freeze damage, which may differentially affect maturity classes will have a similar effect on flavor of sized lots. It is likely that other maturity related quality factors, such as shelf life, will be similarly affected.

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