The Relationship of Peanut Maturity to 2-Methylpropanal in Headspace Volatiles[1]

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Headspace volatiles from peanuts of five consecutive maturity classes from three soil temperatures were determined to evaluate the relationship of peanut maturity and 2-methylpropanal. Cured, ground peanuts were held in closed vials for 30 min at 150 C before headspace sampling. Quantitation as percent of total volatiles and ppm in the peanuts revealed a decrease in 2-methylpropanal as peanuts matured regardless of seed size within maturity class. From peanut lots in which maturity-size relationships had been determined, headspace analysis of commercial sized lots indicated that the concentration of 2-methylpropanal was related to the maturity distribution (percent of each maturity class) within each sized lot. These data/techniques may have application in estimating lot-to-lot maturity-related peanut flavor/quality potential.

Many factors affect peanut quality characteristics such as flavor, shelf-life, blanchability and roasting. Identification and implication of those factors on specific quality characteristics have been the subjects of much research (1). One factor that is consistently recognized as a significant quality factor is maturity. Several studies have demonstrated the compositional differences that exist in peanuts which have been separated by some maturity classification scheme (2-4). Peanuts, however, are not marketed on a maturity basis but on a size basis. Pattee et al. (5), Williams et al. (6) and Sanders et al. (7) have presented data which show a consistent shift to seed size distributions containing higher percentages of large seed in increasing peanut physiological maturity classes. Sanders et al. (7) pointed out that individual lots of commercial sizes of peanuts contain various distributions of maturity classes and suggested that the relative percentages of each maturity stage in sized lots should influence overall lot quality. Peanut size-maturity relationships are influenced by variety, agronomic practices, environment and harvest dates (6,8). Because maturity distribution has a high potential to influence product quality (9), a method to determine relative or acceptable levels of lot maturity may help peanut farmers, buyers and processors make proper quality management decisions for individual lots. Presently there is no method to evaluate the maturity level of individual shelled peanut lots.

In studies on volatiles of peanut maturity classes we noted that the relative concentration of 2-methylpropanal consistently decreased in headspace volatiles from peanuts of increasing maturity (10). This report details those findings and the subsequent use of the information to evaluate relative maturity levels of peanut lots of the same commercial size having different maturity distributions.

MATERIALS AND METHODS

Peanuts (*Arachis hypogaea* L., cv Florunner) used in this study were grown in irrigated, soil temperature modification research plots at the ARS/USDA National Peanut Research Laboratory, Dawson, Georgia in 1982, 1984, and 1985. Geocarposphere temperatures were modified with heating cables or cooling coils installed as described by Blankenship et al. (11) to produce peanuts with different maturation rates (12). Mean soil temperatures 5 cm below the soil surface were ca. 2.5-3.5 C above (heated plot) or below (cooled plot) the mean 5-cm temperature of the ambient plot (ca. 26 C). Mean temperatures were calculated for the treatment period from data collected at 2-hr intervals from 28-30 days after planting (DAP) until harvest (140-150 DAP). Peanuts used for analysis were hand-harvested from randomly selected locations in the 5.5 × 12.3-m plots in 5-Kg lots. Uncured peanut pods were subjected to gentle abrasion with a slurry of small glass beads in water (13) to remove the exocarp and expose the mesocarp color used in Hull Scrape maturity class determinations. Pods were visually sorted into increasing pod maturity classes designated as yellow 1, yellow 2, orange, brown and black. Pod maturity distribution was determined as the weight percent of pods in each class. Numbered classes 3-7, described by Williams and Drexler (14), corresponded to color class designations. In the 1985 crop year, the orange class was subdivided into orange A and orange B. After maturity classification, pods were dried with forced ambient air to ca. 8% moisture. Sample size sometimes precluded use of selected maturity classes. Pods in each maturity class were hand-shelled and volatile analyses were performed on peanuts in a maturity class without regard to size (1982 crop year). In other analyses, pods in individual maturity classes were shelled and seeds were screened into commercial sizes. Designations and seed thickness requirements were jumbo $\geqq$ 8.3 mm > medium $\geqq$ 7.14 mm > number 1 $\geqq$ 6.35 mm > other edible $\geqq$ 5.56 mm. Peanuts of specific maturity classes and specified sizes were then subjected to volatile analysis (1985 crop year). In yet another analyses, pods from the three different soil temperatures, which were harvested at 120 and 150 DAP, were dried, shelled and peanuts were sized without regard to maturity. Peanut lots of comparable commercial size were then subjected to volatile analysis (1984 crop year). Peanuts used in the volatile analysis were randomly selected from the entire sample lots originally segregated by maturity class and/or commercial size. Dried, in-shell pods and shelled seed were stored at 4 C, and analyses were generally completed within five mo of harvest date.

In the volatile analysis, modified from How (15), 25 g of whole, raw peanuts were ground in a Krups 75 coffee mill for 30 seconds. An aliquot of the ground sample (1.5 g) was weighed into a 5-ml vial and sealed with a Teflon-lined silicone disc. The vial and sample were heated in a block heater for 30 min at 150 C. Headspace gas (one ml) from the vial was injected into a Hewlett Packard 5840A

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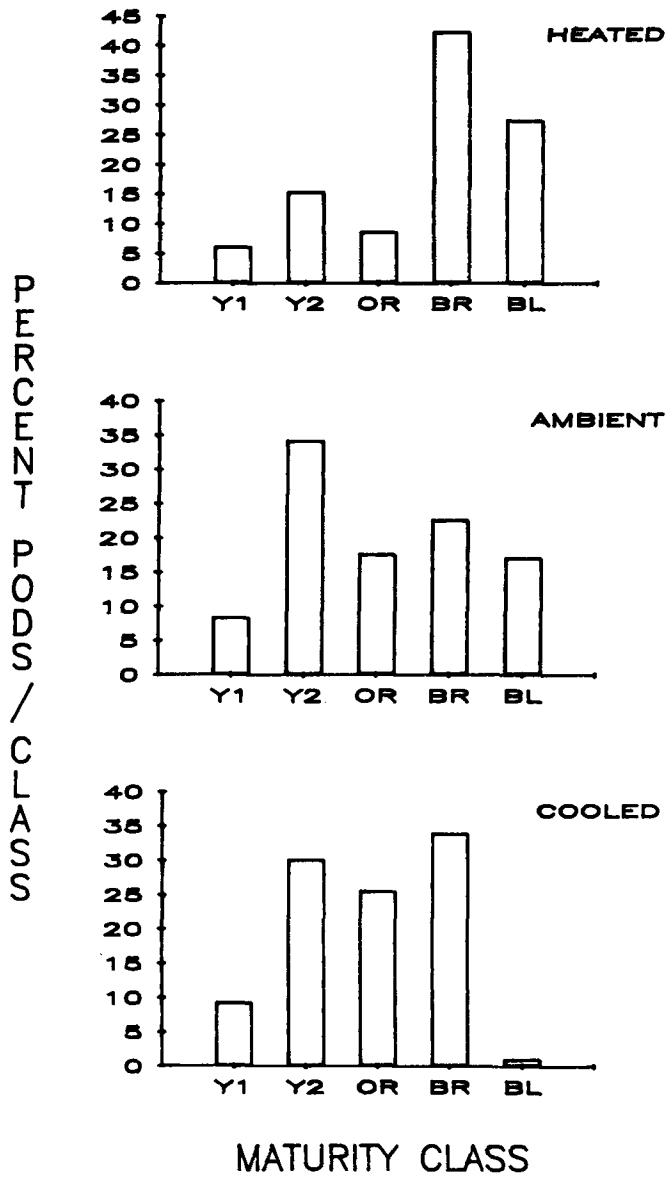

FIG. 1. Typical peanut maturity distributions from plants harvested at 140 days after planting in plots heated (ca. 29 C), ambient (ca. 26 C) and cooled (ca. 23 C) geocarposhpere mean temperatures. Y1, yellow 1; Y2, yellow 2; OR, orange; BR, brown; BL, black.

gas chromatograph fitted with flame ionization detectors. A 1-m × 2-mm (i.d.) stainless steel column packed with Porapak-P, 80-100 mesh was used with helium at 35 ml/min as the carrier gas. The initial column temperature of 100 C for one min was programmed at 20 C/min to 180 C and held for one min. Injection port and detector temperatures were 200 C and 250 C, respectively.

Peaks in the chromatogram tentatively identified by How (15) were verified by GC-MS by M. Legendre, ARS/USDA, Southern Regional Research Center. Peak areas were determined by digital integration, and 2-methylpropanal was calculated as percent of total volatile area counts. All percentage data are the mean of at least two replicated analyses. Concentration (ppm) of 2-methylpropanal from peanuts was calculated using an external standard of 2-methylpropanal.

RESULTS AND DISCUSSION

The indeterminate fruiting pattern of peanuts is well suited to manipulation of maturation rates by varying soil temperature. Moderate changes (ca. 3 C) in mean geocarposhere temperatures accelerate or delay maturation rates. Typical pod maturity distributions (yellow 1 through black) found at ca. 140 DAP on plants from heated, ambient and cooled soils are shown in Figure 1. Seeds of various sizes are contained in the pods of each class, although the percentage of large seed increases with maturity (6,7).

Percentage of 2-methylpropanal in total volatiles decreased from ca. 17% (yellow 1 and yellow 2 were not significantly different) to ca. 6%, and ppm in peanuts decreased from ca. 17 ppm to ca. 1.6 ppm as peanuts matured, regardless of the soil temperature in which they were produced. There were no differences among plots for the same maturity class; therefore, means from the three plots are shown in Figure 2. All size peanuts in each maturity class were used in the analyses. Significant differences were found among 2-methylpropanal percentages for the maturity classes except for yellow 1 and yellow 2. On a ppm basis, the largest differences occurred between the yellow 2 and orange classes. Use of three temperature regimes provided adequate variation to establish that 2-methylpropanal is related to maturity on a consistent basis. Several reasearchers have found maturity-related differences in sugars, amino acids, proteins, lipids and other compounds which may serve as precursors of volatile compounds in peanuts (2-4). Therefore, it is logical that a maturity classification scheme should provide consistent changes in volatile components, as demonstrated by Pattee et al. (16) using uncured seed. The volatile analysis method used in our studies may be described as roasting (150 C for 30 min), and 2-methylpropanal probably results as a Stecker degradation product of valine. Lovergren and St. Angelo (17) found that 2-methylpropanal was produced at increasing rates when ground peanuts were heated at increasing temperatures beginning at 145 C. How (15) found 2-methylpropanal in roasted peanut volatiles and indicated an association of the peak in the GC chromatogram with with the sensory descriptor term "fruity." Lovegren et. al. (18) reported 2-methylpropanal concentrations of 0.8-2.1 ppm in peanut butters found to be acceptable by a trained descriptive sensory panel.

A maturity-size relationship exists in peanuts; however, it is not consistent among production environments (8). To determine if the maturity-2-methylpropanal relationship shown in Figure 2 was affected by seed size, peanuts from maturity classes from each soil treatment were sized into commercial categories and analyzed. Percent and ppm of 2-methylpropanal generally decreased with maturity regardless of seed size (Table 1). In this particular set of analyses the orange class was divided (A and B) to closely examine the class most identifiable with the beginning of metabolic quiescence. These data suggest that sized lots containing peanuts of different maturities might be analyzed for 2-methylpropanal as an indicator of lot maturity.

Percent 2-methylpropanal found in headspace volatiles and ppm of medium size peanuts from plants harvested 120 and 150 DAP from the three soil temperature

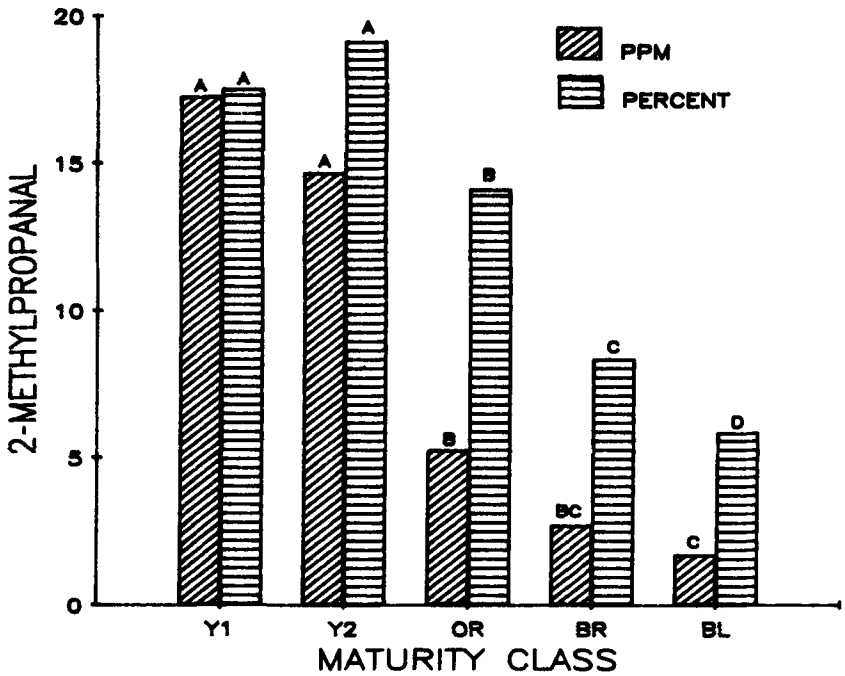

Fig. 2. Percent of 2-methylpropananal in headspace volatiles and ppm from peanuts of Hull Scrape Maturity classes. Data from maturity classes from three soil temperature treatments comprise the means. Means for each type quantification followed by the same letter are not significantly different as determined by Duncan's New Multiple Range Test at the 0.05 level of probability.

TABLE 1

Percent of 2-Methylpropanal in Headspace Volatiles and ppm from Commercial Sizes of Peanuts from Hull Scrape Maturity Classes[a]

Maturity class	Commercial size				Commercial Size			
	Jumbo	Medium	#1[b]	O.E.[b]	Jumbo	Medium	#1[b]	O.E.[b]
	percent				ppm			
Yellow 1	-[c]	25.7	28.9	22.9	-[c]	12.6	12.2	13.7
Yellow 2	20.4	21.3	21.6	24.5	8.9	10.1	11.3	14.0
Orange A	20.6	18.0	17.8	20.6	7.6	7.7	7.9	9.3
Orange B	14.4	15.7	16.1	16.4	6.1	5.7	4.8	6.8
Brown	12.3	10.4	10.0	12.2	3.4	3.3	3.0	3.2
Black	7.0	9.6	8.5	-[c]	2.4	2.3	2.1	-[c]

[a]Values are the mean of 2-6 analyses depending on availability of seed sizes from each maturity class from each soil temperature treatment.
[b]#1, Number 1; O.E., Other edible.
[c]Not available for analysis.

treatments are shown in Table 2. At 120 DAP percent and ppm of 2-methylpropanal was significantly different in peanuts from each plot. Peanuts from cool soil had the largest quantities which, based on Figure 2, relates to the most immature lot; those from the heated plot had the lowest and thus were the most mature, although they were all the same size category. At 150 DAP the quantities of 2-methylpropanal in the heated and ambient treatment peanuts were similar, but peanuts from the cool treatment had significantly more 2-methylpropanal. The 120 DAP harvest represents an early harvest date for Florunner peanuts, while the 150 DAP is near optimum harvest date or slightly past optimum. Knowing the seed size distribution of each maturity class from each plot and the total weight of each maturity class from each plot (data not presented) allowed the calculation of the maturity distribution in medium size peanuts harvested at 120 and 150 DAP (Fig. 3). Percent of immature peanuts decreased in the medium size category as soil temperature increased. This fact was more obvious at 120 DAP than at 150 DAP. However, the cool plot at 150 DAP contained more immature peanuts than the ambient and heated plots, which were similar. The maturity distribution data parallels the 2-methylpropanal data for peanuts from the three plots. Similar results were found for peanuts from the jumbo and No. 1 commercial size categories (data not

TABLE 2

Percent of 2-Methylpropanal in Headspace Volatiles and ppm from Medium Sized Peanuts[a]

Harvest date	Percent of total volatiles Soil treatment			Concentration Soil treatment		
	Cooled	Ambient	Heated	Cooled	Ambient	Heated
	percent			ppm		
120 dap	23.6 a[b]	16.8 b	12.0 c	11.2 a	5.9 b	3.5 c
150 dap	14.1 a	10.9 b	10.8 b	4.9 a	2.7 b	3.3 b

[a]From plants harvested at 120 and 150 days after planting (DAP) from plots with different geocarposphere temperatures.
[b]Means for a harvest date followed by the same letter are not significantly different as determined by Duncan's New Multiple Range Test at the 0.05 level of probability.

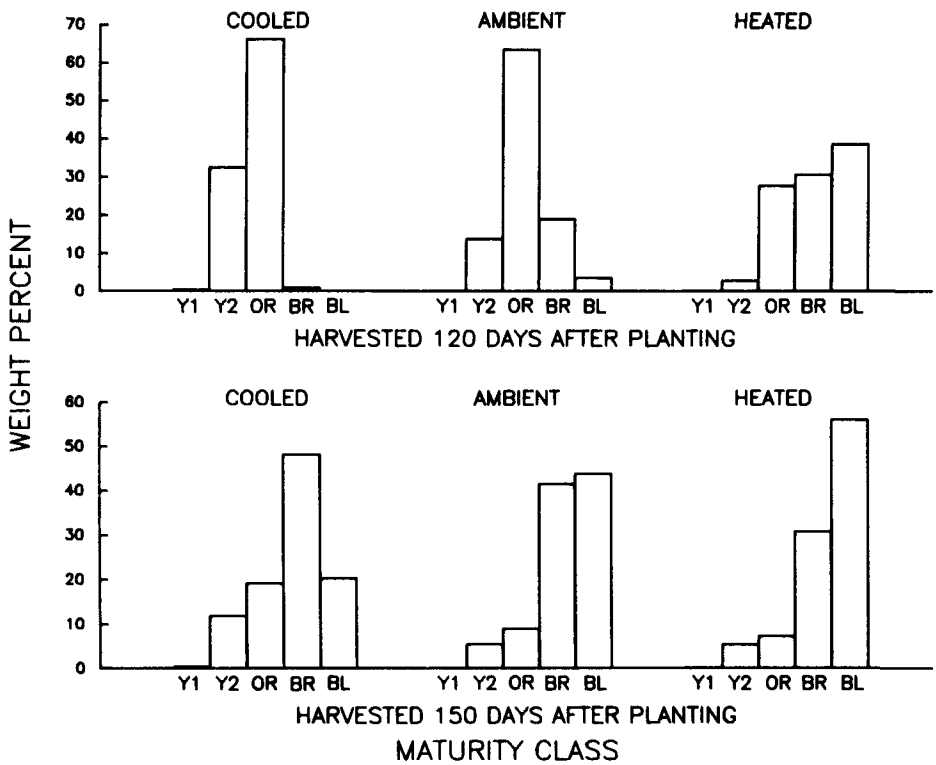

FIG. 3. Maturity distribution in medium size peanuts from plants harvested at 120 and 150 days after planting from plots with different geocarposhpere temperatures. Y1, yellow 1; Y2, yellow 2; OR, orange; BR, brown; BL, black.

presented). The data presented indicate a consistent relationship between maturity distribution within a lot of sized peanuts and quantity of 2-methylpropanal in those peanuts. Potential exists for use of this compound as an indicator of overall comparative lot maturity. Because peanut maturity affects roast color and flavor (9), this data/technique may prove useful in determining lot-to-lot quality for directed manufacturing end use or as an early indicator of quality in the market grading system for peanuts.

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