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Oil Characteristics of Peanut Fruit Separated by a Nondestructive Maturity Classification Method

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ABSTRACT

A nondestructive peanut pod maturity classification method, Pod Maturity Profile (PMP), based on visual examination of the color and structural characteristics of pod mesocarp after partial removal of pod exocarp, was used to separate freshly harvested peanut pods into maturity classes. The separations made nondestructively were compared with those made by a method involving the examination of internal pericarp and testa characteristics. The groups separated by the two methods were closely related. In oil from the PMP classes, color decreased, free fatty acid content decreased, iodine value remained approximately constant, and oven stability of the extracted oil increased with increasing maturity. Total oil contents and fatty acid profiles had consistent but more complex relationships with maturity. The data indicate that the PMP method allows consistent and reproducible classification of peanut fruit maturity.

Key Words: *Arachis hypogaea*, peanut, maturity, Physiological Maturity Index, Pod Maturity Profile, peanut oil, oil stability, peanut quality.

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Studies involving peanut maturity are complicated because the maturation process is continuous and not com-

posed of distinct stages. However, to examine physiological changes that are occurring during maturation, some separation of defined maturity stages must be made. Since each maturity stage necessarily represents a small and slightly overlapping range of physiological characteristics, investigation of physiological differences requires a consistently accurate basis of classification. Methods to determine peanut maturity by color and morphological characteristics of the seed, testa, and internal pericarp have been reviewed (11). Although considerable time and effort are involved in examining the characteristics of each pod, the accuracy and reproducibility of the physiological maturity index (PMI) of Pattee et al. (6) has been demonstrated in several studies (6, 7, 8, 9). The pod maturity profile (PMP) classification of Drexler and Williams (4, 11), based on characteristics of pod mesocarp after partial removal of exocarp, provides a novel approach to maturity classification since pods of different maturity may be separated without substantial damage to pod structure. Working with intact pods of known maturity stages will provide unique opportunities in curing, pathology, physiology, microbiology, and other areas of peanut research. However, before such work is attempted, some measure of the physiological relationship of the various maturity classes should be accomplished by examination of seed from the nondestructively classified pods. Such an examination should also demonstrate the reproducibility of the method and that peanuts in the same maturity class harvested at different times in the growing season are physiologically similar.

The objectives of this study were to determine oil characteristics of PMP classes and thus demonstrate a consistent physiological relationship among the classes which may be compared to published information on PMI stages, demonstrate the reproducibility of the PMP method, and compare PMI and PMP classifications on the same peanut lots.

Materials and Methods

Florunner peanuts were planted at the Coastal Plain Experiment Station, Tifton, Georgia on 5/1/78, 5/12/78, 5/22/78, and 6/1/78. Conventional planting and cultural practices were used. Sample plants were dug at six weekly intervals beginning 8/29/78 for the first two planting dates and 9/7/78 for the others. Peanut pods were removed from the plants and separated into maturity classes based on characteristics of pod mesocarp at or near the basal seed attachment point after partial removal of exocarp as reported by Williams and Drexler (11). Pods were gently dried to 5-8% moisture and stored in mesh bags at about 4 C until utilized. Four composite samples, one per planting date, were used unless otherwise noted. For each sample, peanuts from six different harvests during the growing season were combined to allow maximum phenotypic expression of environmental effects on the classes.

Peanut pods in each maturity class were hand shelled, and the seeds ground in a hammer mill. Oil, expressed with a Carver Laboratory Press maintained at approximately 8.2×10^3 Kg for 15 min, was vacuum filtered through a glass fiber filter (Reeve Angel AH934) and placed in a brown glass bottle at 2 C.

Total oil was determined by a method similar to AOCS Method Ab 3-49 (1) except that oil from the ground seed was extracted with extraction thimbles in Soxlet extractors. Free fatty acids (FFA) in the pressed oil were determined by the titration procedure of AOCS, Method 6-38 (1). Oil color and iodine value were determined by APREA Methods B-2, Maturity and B-3, Iodine Value, respectively (2). Fatty acid profiles were determined by GLC as previously described (9). All assays, except oil stability, were completed within 24 hr of oil extraction.

The stability of press-extracted oil was determined by the method of Young and Holley (10). Triplicate oil samples of about 450 mg each were placed in 40-ml crucibles and subjected to 60 C in a forced air oven. Samples were weighed at regular intervals and the number of days required for the first rapid weight gain of 1 mg was recorded as the length of stability in oven days.

The PMI method of Pattee et al. (6) and the PMP method of Williams and Drexler (11) were compared on peanuts grown in Tifton, Georgia in 1979. Pods from three separate harvests during the growing season were first separated by the PMP method into maturity classes; then, each class was subdivided into PMI stages. The percentage distribution of stages defined by Pattee et al. (6) within the PMP (11) classes was determined.

Results and Discussion

The terms "PMI stage" and "PMP class" (or, simply, "stage" and "class") are for identification only since both separations result in various physiologically different groups. The PMP method identified seven morphological maturity classes, each of which may be subdivided into four increments (11). With each subdivision, separation becomes more complex and subject to more overlapping of physiological groups. For the purposes of this study, classes were not subdivided and only the whole number classes 2-7, as described in Table 1, were utilized (i.e., class 7 includes 7.0, 7.25, 7.5 and 7.75). The PMI is a system of 14 maturity stages separated according to color and morphology of the testa and internal pericarp (6). A comparison of the distribution of peanut seeds classified by the PMI and the PMP classification methods is provided in Table 2. The comparison indicates that changes in the external physical and morphological characteristics of the pod mesocarp closely parallel changes in the internal pericarp and testa, since in each PMP class over 70% of the pods were placed in no more than two PMI stages. This comparison allows evaluation of past and future data obtained by the two methods.

Table 1. Pod maturity profile class characteristics.

Class	Mesocarp Color [a]	Exocarp Characteristics
1	white	initial development, smooth, soft, watery
2	white	reaching maximum size, soft, watery. longitudinal venation distinct, net venation on basal segments beginning
3	very pale yellow	net venation nearly complete to complete, slightly rough, somewhat resilient
4	dark yellow	somewhat rigid to rigid structure, distinct reticulation
5	orange to brownish orange	rough, rigid, reticulated
6	reddish brown to brown	rough, very rigid, reticulated
7	black	rough, very rigid, reticulated

[a] Median class color of mesocarp at or near the basal seed attachment point.

Table 2. Comparison of peanut maturity classification methods[a]

Pod Maturity Profile Class [b]	Physiological Maturity Index Stage								
	5	6	7	8	9	10	11	12	13
	% in each stage								
2	44.8	34.5	13.8	6.9					
3	4.9	15.9	34.9	43.6	0.7				
4			11.4	65.2	23.2				
5			0.1	6.7	44.3	35.8	13.1		
6					0.1	5.0	41.2	45.6	7.2
7							4.9	54.2	40.9

[a] Pod maturity profile classes separated into physiological maturity stages, numbers expressed as % of total. Each value is the mean of three replications.

[b] Each pod maturity profile class contained a minimum of 150 pods.

PMI stage 6 pods are morphologically distinct from those of the preceding stages in that cracks are present in the thick, white internal pericarp. This PMI stage corresponded to PMP classes 2 and 3. For pods in these two classes, exterior mesocarp colors range from white to very pale yellow; pod venation, from distinctly longitudinal to net-like; and pod structure, from soft to slightly resilient. Colors of PMP classes refer to the most advanced color of the mesocarp at or near the basal seed attachment point. PMP class 5 corresponded closest to PMI stages 9 and 10. Externally, class 5 pods have an orange to brownish-orange mesocarp and have generally complete morphological pericarp characteristics. Internally, pods at PMI stages 9 and 10 have distinct brown splotches on the internal pericarp and testae that are generally pink and just beginning to dry out. In Table 2, pods with light tan splotches on the internal pericarp are included in PMI stage 9, although a distinct brown splotching is more characteristic of the stage. Inclusion of these pods in stage 9 is especially evident in the distribution of PMP class 4. The more mature PMI stage 9 pods correspond to the point where pods are often separated into "mature" and "immature" groups by the shellout maturity method. PMP classes 6 and 7 represent a change in external mesocarp color from reddish brown to brown to black and correspond to PMI stages 11-13. At these stages, pods have brown or black splotches over at least half the internal pericarp. The comparison made (Table 2) indicates that the PMP method can be used to separate peanuts into maturity classes that correspond well to the PMI stages used in several previous studies (6, 7, 8, 9).

Peanut oil content and composition have been shown to change progressively in PMI stages (8) and several quality factors of the PMP classes followed similar progressions in this study. Total oil as a percentage of dry weight (Table 3) increased significantly through class 5 and decreased slightly in class 7. Correspondingly, the most rapid changes in total oil occurred in early maturity stages and correspond to the time of very rapid increases in seed dryweight (8).

Table 3. Oil Characteristics of Peanut Pod Maturity Profile Classes[a]

Maturity Class	Oil % D.W.	Oil Color[b]	Free Fatty Acid[c]	Iodine Value	O/L[d] Ratio
2	33.1 a	1.71 a	0.88 a	97.6 a	1.29 a
3	41.9 b	0.98 b	0.29 b	96.6 b	1.44 b
4	47.0 c	0.72 bc	0.18 c	96.8 b	1.50 bc
5	49.7 d	0.43 cd	0.09 cd	97.0 ab	1.56 c
6	49.1 de	0.15 d	0.05 d	96.9 ab	1.65 d
7	48.1 e	0.07 d	0.05 d	96.7 b	1.65 d

[a] All data are the mean of composite samples from each of four planting dates. In each column, means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

[b] Optical density

[c] % as oleic acid

[d] O/L = oleic acid/linoleic acid

Oil color generally decreased with increasing maturity (Table 3). In any conventionally-harvested lot of peanuts, the overall oil color will depend on the relative proportions of the various maturity classes. Unfortunately, different environmental and cultural practices, such as drying treatment, often significantly affect oil color from one location to another and preclude its use as a general index of maturity. In this study using standard cultural pracitices, oil color was related to maturity even though environmental factors differed somewhat (i.e., peanuts comprising the four samples were harvested at various times during the growing season).

FFA decreased as peanuts matured through PMP class 5 (Table 3). The largest decrease occurred in the earliest maturity classes with no significant difference among the three most mature classes. FFA's as determined by GLC for petroleum ether-extracted oil from physiological maturity stages were higher (8) but followed the same decreasing trend with increasing maturity. The relatively high values may have been due to the fact that the seed had been frozen and stored before they were extracted with petroleum ether.

Iodine value, as determined by refractive index, changed very little with maturity (Table 3). The lack of change could be anticipated from the fatty acid profile presented in Table 4. In the PMP classes examined, oleic acid increased about 8 mole percent, linoleic acid decreased about 2.5 mole percent, and eicosenoic acid decreased about 0.5 mole percent. Although there were changes in concentration of various fatty acids, the overall change in unsaturation on a molar basis was relatively small.

The O/L (oleic acid/linoleic acid) ratio (Table 3) changed in a manner similar to FFA, in that the largest changes occurred in the more immature classes. These changes reflect the fact that significant differences between classes were more consistent for oleic acid than for linoleic acid (Table 4).

Oven stability of press-extracted peanut oils generally increased with maturity (Table 5). As with other oil characteristics the degree of change decreased substantially as peanuts began to reach class 5, the beginning point of physiological maturity. The data suggest that storability and other quality factors of peanuts may be influenced by the overall maturity level of a crop harvested by conventional practices.

Oven stability of the pressed oil was highly correlated with oil color ($r = 0.98$), percent FFA ($r = 0.97$), percent linoleic acid ($r = 0.90$), percent oleic acid ($r = 0.97$), and the oleic/linoleic acid (O/L) ratio ($r = 0.93$). No report of similar findings was found in a literature review, and whether or not the relationship of oil color and oxidative stability is consistent for whole seed, maturity classes, and harvested lots, may warrant further investigation. Brown et al. (3) reported poor correlation between FFA of freshly pressed oils and keeping time, but reported a correlation of -0.78 for coldpressed, aged (1 month at 4 C) oil. The correlations in their work may have been difficult to determine since the FFA range was only 0.02 - 0.06%. In our study, FFA ranged from 0.05 - 0.88%.

Fore et al. (5) found that the relative linoleic acid content of peanut oils from different varieties was one of the major factors affecting variation in oil stability. The range of linoleic acid in those tests was 19.9 - 37.0%, far more

Table 4. Fatty Acid Composition of Oil from Peanut Pod Maturity Profile Classes.

Maturity Class	16:0	18:0	18:1	18:2	20:0	20:1	22:0	24:0
				Mole %				
2	13.51 a	2.01 c	42.37 a	32.87 a	1.31 a	1.75 a	4.54 a	1.64 a
3	12.28 b	2.09 ab	45.55 b	31.73 ab	1.31 a	1.63 b	3.82 b	1.59 a
4	11.88 c	2.12 a	47.27 c	31.43 b	1.27 ab	1.47 c	3.15 c	1.42 b
5	11.48 d	2.11 ab	48.66 d	31.28 bc	1.23 b	1.31 d	2.64 d	1.29 c
6	11.49 d	2.03 bc	50.07 e	30.44 c	1.18 c	1.24 e	2.36 e	1.20 d
7	11.45 d	2.00 c	50.20 e	30.47 c	1.16 c	1.23 e	2.33 e	1.17 d

All data are the mean of composite samples from each of four planting dates. In each column, means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

Table 5. Oven Stability of Press-Extracted Peanut Oil from Pod Maturity Profile Classes

Class	60 C Oven days
3	18.0 a
4	20.3 b
5	24.3 c
6	25.0 cd
7	26.6 d

All data are the mean of composite samples from each of four planting dates. Means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

than the 2.5% maximum difference we noted in our maturity study. Of the O/L ratios for the oils that Brown et al. (3) extracted, using various solvents, the O/L ratio for the oil extracted with chloroform:methanol (3:1) correlated best ($r = 0.91$) with keeping time. In our study, the high correlation between O/L ratio and oven stability of pressed oil ($r = 0.93$) might be expected since correlations between stability and each fatty acid were high.

Conclusions

Although color perceptions and evaluations of various specific characteristics of peanut pods may vary slightly between personnel using the PMP classification method, the relationship of external mesocarp color to maturity is obvious and, according to the data presented, is reproducible throughout the growing season. As with all environmentally-affected biological systems, some yearly variation is expected. However, based on our data derived from seed which received a wide and differing range of environments due to varying planting dates and harvest dates, these variations do not appear to be significant problems affecting the use of the PMP classification method.

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