# A Visual Method of Determining Maturity of Shelled Peanuts[1]

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**ABSTRACT**

To assess maturity distributions of shelled-stock peanut lots, a method was developed to characterize peanut kernels into one of three possible maturity classes based on testa texture and color and kernel shape. Kernels having testa with longitudinal wrinkles, a raisin-like texture, light color and slightly elongated shape were classed Immature and predominately were shelled from pods in the Hull-Scrape categories White, Yellow I, and early-Yellow II. Kernels with a smooth testa, pink to dark pink and with a more rounded appearance were classed Mid-mature and predominately were shelled from pods in the late-Yellow II, Orange, and early-Brown Hull-Scrape classes. Kernels with a waffle-like surface texture, dark pink to brown testa, and a more rounded appearance were classed as Mature, and predominately were shelled from pods in the mid- and late-Brown and the Black Hull-Scrape categories. Attempts to automate the system using color alone were unsuccessful; to be a reliable maturity sorting technique, both testa texture and color pattern had to be considered.

Key Words: Testa, surface texture, kernel, shape.

The peanut's indeterminate fruiting pattern results in the harvested crop consisting of seeds of different maturity. Williams *et al.* (1987) reported that maturity and size of kernels within a cultivar are related. Therefore, the current size related market classes of shelled stock peanut (Jumbo, Medium, No. 1) reflect a degree of maturity. However, kernel size and maturity are not perfectly correlated (Sanders, 1989). Varying environmental conditions can result in small mature kernels or large immature kernels.

Tollner and Hung (1993) used NMR readings for moist and dried peanuts to assess peanut maturity. In 1987, Whitaker *et al.* found that Near Infared Redlectance (NIR) could be used to measure kernel maturity.

Past research has determined that 'shriveled' or 'wrinkled' testa are indicators of immaturity (Parham, 1942; Mixon, 1963; Aristizabal *et al.*, 1969). Pickett (1950) noted that a reliable and simple method of determining maturity of developing peanut kernels included a combination of seed texture and testa color. Schenk (1961) also used kernel surface texture (wrinkled, smooth) and testa color (white to pink to red with brown splotches) to describe the seed maturing process. Pattee *et al.* (1970 and refined in 1974) gave a detailed description of characteristics associated

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with kernel maturity using shape, testa color, and texture. This work characterized kernel development into 15 distinct stages using shape, testa color, and texture patterns.

In 1981, Williams and Drexler proposed a nondestructive method to determine peanut pod maturity based on pod endocarp coloration. This method became the basis of the Hull-Scrape technique now used to determine best harvest date. Many projects now rely on the Hull-Scrape to determine digging and relative maturity of the crop.

To rapidly assess maturity distributions of shelled stock peanut lots, a method to relate the Hull-Scrape maturity categories to kernel maturity is needed. In this manuscript, we propose a simple technique to classify individual kernels into one of three maturity classes based on previously studied shape, testa color pattern and texture relationships, and to relate those classes to Hull-Scrape categories.

## Materials and Methods

Florunner cultivar peanuts were planted during the first week of May during the 1988, 1989, 1992, and 1993 growing seasons at the Gibb's research farm near Tifton, GA, in a Tifton loamy sand soil type (fine-loamy, siliceous, thermic Plinthic Kandiudult). Harvest date was determined using the Hull-Scrape method. At harvest, a 9-m row of plants was dug and immediately all pods were hand picked off the vines. Pods were then scraped with a pocket knife in the saddle area and classified into the Hull-Scrape categories of Yellow I, Yellow II, Orange, Brown, or Black, and a representative 50-pod sample was collected for each Hull-Scrape color class. Each pod was weighed, then hand shelled, and hull and kernels weighed and components of each pod placed into a coin envelope. All hulls and kernels were oven dried together at 32 C for 18 hr to remove moisture. After drying, hulls and kernels were weighed to determine dry weight. Kernels within each Hull-Scrape class were observed for visual characteristics related to maturity, including testa color, surface texture, and kernel shape. In addition to visual ratings, eight kernels from each group were randomly chosen for spectral analysis (1988 and 1989 only). Reflectance from 20 kernels of each Hull-Scrape color class were analyzed for specific color content by Sortex-Scanore (Union City, CA) using a Spex Model 1681 Spectrometer (Spex Inc., Edmonton, NJ) coupled to a microcomputer. Wavelengths from 375 to 750 µm were tested. From these observations, visual characteristics related to maturity were recorded and correlated to the Hull-Scrape method.

## Results and Discussion

***Testa Characteristics.*** Because processing studies generally require large sample sizes, a system with a minimum number of kernel maturity classes was desired. From the past work of Pickett (1950), Schenk (1961), Pattee *et al.* (1970, 1974), and our preliminary studies, we determined that three kernel maturity classes (Immature, Mid-mature, and Mature) could be easily identified and related to the basic Hull-Scrape color classes. The physical characteristics used to establish the three kernel maturity classes were based on shape, testa color pattern, and surface texture.

Physiological development of the pod and kernel result in changes in testa characteristics which are related to kernel maturity. Pod size is set early in development; Schenk (1961) found cv. Virginia Bunch 67 pods had attained maximum size 3 wk after the pegs had entered the ground. At this stage of development, the kernels are very small and both the pod and the seed are comprised mostly of water; the testa surrounding the immature seed is thick and fleshy in relation to the seed.

Studies by Pattee *et al.* (1970, 1974) with cv. NC 2 noted that immature kernels tend to be torpedo-shaped, with the testa color varying from pink (embryonic end) to white. Pickett (1950) noted that immature seeds averaged 62% moisture at harvest. After curing, immature kernels were noticed to have a raisin-like appearance with longitudinal wrinkles (Parham, 1942, Mixon, 1963). Kernels with these characteristics were classed as "Immature" (Fig. 1). Like Pickett (1950), we found the immature pods and seed to have approximately twice the moisture percentage as mature pods and seed (60 vs. 30%, Table 1).

Because pods in the Hull-Scrape category of White are very immature and rarely harvested (the combine blows them out the back), we confined our comparisons between kernels and Hull-Scrape classes to Yellow I and beyond. Cured kernels from the Hull-Scrape categories Yellow I and early-Yellow II had testa with longitudinal "wrinkles" resulting from the drying of a thick fleshy testa covering a high moisture seed (>50%) which was significantly reduced in size once this moisture was removed (Table 1). In addition, the length to width ratio (L/W) of immature kernels was significantly higher (ave. 1.66) than in mature kernels (ave. 1.42, Table 2). Therefore, kernels from pods in the Hull-Scape categories of Yellow I and at least the first half of Yellow II would be classified as "Immature" (Fig. 2). This Immature class would encompass up to stage seven of the kernel maturity classification system developed by Pattee *et al.* (1970, 1974).

**Table 1. Fresh and dry weight and percentage water loss o pods and seed within each Hull-Scrape class.**

| | Pod | | | Seed | | |
|---|---|---|---|---|---|---|
| | Fresh wt | Dry wt | Moisture | Fresh wt | Dry wt | Moisture |
| | ----g---- | | % | ----g---- | | % |
| **Hull scrape class** | | | | | | |
| Black | 2.2 B[a] | 1.6 A | 28 E | 1.8 BC | 1.3 A | 28 E |
| Brown | 2.3 AB | 1.5 AB | 32 D | 1.8 AB | 1.3 A | 31 D |
| Orange | 2.4 A | 1.5 B | 37 C | 1.9 A | 1.2 A | 35 C |
| Yellow 2 | 2.2 B | 1.2 C | 42 B | 1.7 C | 1.0 B | 40 B |
| Yellow 1 | 1.8 C | 0.8 D | 52 A | 1.2 D | 0.7 C | 49 A |
| **Kernel maturity** | | | | | | |
| Mat - Mat[b] | 2.2 A | 1.5 A | 30 E | 1.8 A | 1.3 A | 29 E |
| Mat - Mid | 2.3 A | 1.5 A | 35 D | 1.8 A | 1.2 A | 33 D |
| Mid - Mid | 2.2 A | 1.3 B | 41 C | 1.7 A | 1.1 B | 38 C |
| Mid - Imm | 1.9 B | 0.9 C | 52 B | 1.3 B | 0.7 C | 49 B |
| Imm - Imm | 1.7 C | 0.7 D | 62 A | 1.0 C | 0.4 D | 59 A |

[a]Within a column, means followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's Multiple Range Test.

[b]Mat = Mature, Mid = Mid-mature, Imm = Immature.

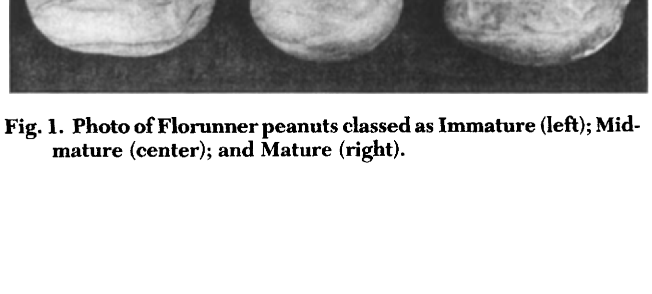

**Fig. 1. Photo of Florunner peanuts classed as Immature (left); Mid-mature (center); and Mature (right).**

Table 2. The influence of maturity on Florunner kernel length/width ratio by market class.

| Market class | Length/width ratio Immature | Mid-mature | Mature |
|---|---|---|---|
| No. 1 | 1.73 A[a] | 1.42 B | 1.37 B |
| Medium | 1.63 A | 1.47 B | 1.39 C |
| Jumbo | 1.62 A | 1.45 B | 1.44 B |
| All Classes | 1.66 A | 1.43 B | 1.42 B |

[a]Within a row, means followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's Multiple Range Test.

As the pod and seed development proceeded, kernels tended to become more rounded, and testa color moved from white towards its mature color [which in studies by Pattee *et al.* (1970, 1974) with NC 2 was dark pink to brown]. At this point in maturity, the testa becomes less fleshy and the moisture content drops to approximately 40% (Table 1). After curing, seeds in this intermediate maturity group have a smooth surface and a more rounded shape (L/W = 1.43). Schenk (1961) noticed this change approximately 7 wk into the development of Virginia Bunch 67. Kernels having a more rounded shape with testa having a smooth surface texture and a pink color we classified "Mid-mature". Cured kernels from the Hull-Scrape classes of late Yellow II, Orange, and early Brown fell into this mid-mature class (Fig. 2). The Mid-mature class would encompass stages 8, 9 and 10 of the kernel maturity classification system of Pattee *et al.* (1970, 1974).

As the pods matured further into the Brown and Black Hull-Scrape categories, both kernels and pods reached maturity and moisture content dropped to approximately 30% (Table 1, Fig. 2). At this stage, the kernel had grown to completely fill the interior of the hull and pressed tightly against it, resulting in small waffle-like indentations on the kernel surface from contact with the inner hull surface (Fig. 1). This contact results in a brown splotching of the testa as some of the inner hull color transfers to the testa.

In the case of Florunner, as with NC 2 and Virginia Bunch 67, as the seed matured the testa darkened, changing to darker pink and then towards brown (Pattee *et al.*, 1970, 1974; Schenk, 1961). The shape of the mature seed were similar to those we classed as Mid-mature (L/W = 1.43, Table 2). Individual kernel dry matter also reaches maximum at this stage. When kernels showed evidence of the waffle like imprint of the hull and brown blotching we classified them as "Mature". The Mature class would encompass stages 11 through 15 of the kernel maturity classification system of Pattee *et al.* (1970, 1974).

As did Schenk (1961), we also noted basal kernels to be slightly (approximately 5 d) more mature than apical kernels (Fig. 2). Because the Hull-Scrape procedure is based on the coloration of the pod endocarp in the saddle area of the pod (where the basal seed is attached), the Hull-Scrape best reflects the maturity of the basal kernel. Environmental stresses may result in a small percentage (<5%) of immature kernels in the Brown and Black Hull-Scrape categories, resulting from a mature basal kernel paired with an immature apical kernel. These infrequent large deviations between basal and apical kernel maturities can be brought on by water, calcium or other stresses. Similarly, small percentages of mature kernels can be found in the Yellow-I and Yellow-II pod classes resulting from an immature basal kernel and a mature apical kernel. The correlation coefficient between the Hull-Scrape categories and the proposed kernel maturity classes was 0.77 (P<0.0001).

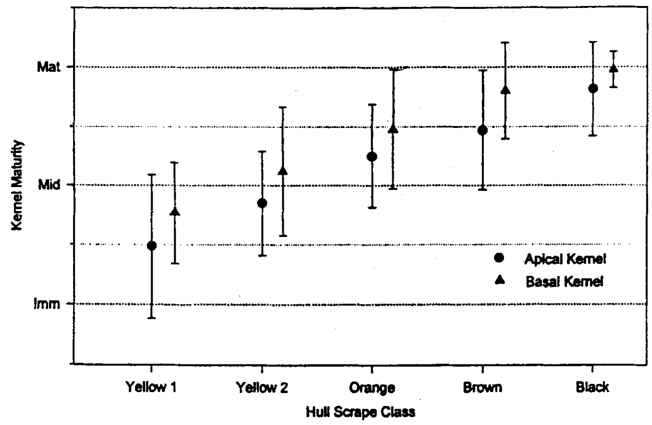


Fig. 2. Mean apical and basal seed maturity as related to Hull-Scrape Maturity.

When L/W of kernels was analyzed according to maturity groups, a significant maturity related change was found in every market class (Jumbos, Mediums, and No. 1s) (Table 2). Immature kernels had an average L/W (over all market classes) of 1.66; mid-mature kernels 1.43, and mature kernels 1.42. Therefore, kernel L/W could be used to help separate immature kernels from the mid-mature and mature kernels, but does not appear reliable in sorting mid-mature kernels from mature kernels. A summary table of the maturity related kernel characteristics is provided in Table 3.

While the results of this experiment were specific to Florunner peanut, the method of determining kernel

Table 3. Description of testa characteristics, kernel shape, and the comparable Hull-Scrape class of kernel maturity classes Mature, Mid-mature and Immature.

| Kernel maturity | Testa characteristics | Kernel shape | Comparable Hull-Scrape class |
|---|---|---|---|
| Immature | White to light pink longitudinal wrinkles giving raisin-like appearance | Elongated length/width ratio average 1.7 | White to mid-Yellow II |
| Mid-mature | Pink to dark pink, smooth testa surface | More rounded, length/width ratio average 1.4 | Late-Yellow II to early-Brown |
| Mature | Dark pink to brown, surface with waffle-like appearance and brown splotches from contact with hull | More rounded, length/width ratio average 1.4 | Mid-Brown through Black |

maturity described in this manuscript should work with many other cultivars. Slight adjustments in the descriptors for testa colors may be necessary for different cultivars. However, since testa texture and kernel shape characteristics are based on the physiological development of the kernel during the maturing process, we expect texture and shape relationships to maturity to be stable across cultivars.

***Spectral Analysis.*** When large populations of each maturity group were compared, a slightly darker color was noticeable, particularly in the mature group. The darker color, in part, is associated with the previously mentioned brown patches on the testa. Therefore, we conducted a study to determine the feasibility of using spectral analysis to sort kernels into maturity classes based on changes in maturity related testa characteristics. Spectral charts (wavelength vs. reflectance) of individual kernels indicated little color differences between maturity groups. The wavelengths seeming to have the most potential for a maturity related differential in light absorption were in the range of 580-610 μm. However, kernel to kernel variation was too great for these spectra to be reliably used in sorting. When individual kernels were further analyzed as to specific color content and plotted on a CIE chart, the differences in color were scattered, with no maturity related pattern found. Therefore, with current technology, we concluded that an automated kernel maturity sort based strictly on testa color (within the wavelengths tested) would not be reliable. Systems which are capable of discriminating surface textures or shapes may be more reliable.

## Summary

Shelled-stock kernels can be rapidly sorted into maturity groups based on a combination of testa surface and color characteristics. The three kernel maturity groups (Immature, Mid-mature, and Mature) strongly correlated to the in-shell, Hull-Scrape classes of Yellow I and early Yellow II; late Yellow II, Orange and early-Brown; late-Brown and Black, respectively. Attempts to automate the kernel maturity sorting based solely on testa color were unsuccessful. It was the combination of testa surface texture and color changes (based on the physiological development of the kernel) that made this method reliable.

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