Accuracy of Peanut Moisture Determinations by Using the Official AOCS Method[1]

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ABSTRACT

A collaborative study was conducted using Spanish peanuts at Oklahoma State University and Virginia peanuts at North Carolina State University regarding the variability in moisture determination using the official AOCS method. The variability among 30 samples was estimated at 5 moisture levels for each of the two peanut types. No difference could be detected between the two types and the data were combined. The standard deviation was linearly related to the mean moisture. Data provided information necessary to compute the number of samples required for a desired precision.

Accurate knowledge of the moisture content of peanuts is important during harvest, curing, and storage. At the time of sale, moisture measurements are used to determine price and storability. The seller desires high moisture content to produce the most saleable weight and the buyer desires low moisture content for cost and safe storage.

Moisture standard determinations for peanuts are made by oven drying procedure. Different temperatures have been used depending on what purpose the moisture content is needed. Higher temperatures are used because of short time and lower temperatures are used because of possible oil changes. It is not vitally important which procedure is used so long as the procedure is universally adopted and results are reproducible and comparable (Pixton, 1967). A survey by Young (Personal Communication, 1973) reported that six different oven drying procedures are used by scientists working with peanuts. The most popular method was the American Oil Chemists Society official (AOCS) method, Ab2-49, for moisture in products with volatile matter.

Differences in moisture contents of peanut pods for mixtures of mature and immature peanuts were measured by Blankenship and Hutchinson (1971). For Spanish peanuts immediately after drying the moisture difference between mature and immature pods was 8 percentage points. This differential was reduced considerably after storage. Brusewitz (1974) measured the variation in moisture content among peanut pods after drying; standard deviations as large as one-third the average moisture content were not uncommon. Brusewitz (1973) reported that circulation of air was instrumental in reducing the variability among kernels and that the variability was considerably greater for the shell than for the kernel. The shell responds more than the kernel to fluctuations in the environmental moisture levels. Greenblau (1960) found that peanut samples, when finely divided and mixed, yielded more repeatable results than whole pods and that results were more comparable to the Brown-Duvel distillation test.

The objective of this study was to determine the accurancy in moisture content determination by using the AOCS Standard Ab2-49.

Materials and Methods

Moisture was determined by the AOCS method, on Spanish peanuts at Oklahoma State University and on Virginia peanuts at North Carolina State University. At each location, 30 samples of kernels, hulls, and pods were measured at each of several moisture contents. The variance of the 30 determinations at each moisture content was determined.

Peanuts were dug at optimum maturity and combined green. They were brought to the laboratory and dried in thin layers with forced room air at approximately 25°C and 60% relative humidity. The desired final pod moisture content levels were 6, 11, 25, 43, and 67% dry basis (D.B.) At the end of the drying period the lots were sealed in plastic bags and stored at 2-4°C until moisture determinations could be made. Foreign material and obvious "pops" were hand removed, thirty 200-g samples were selected from each lot, and each sample was analyzed by the official AOCS method for moisture. Briefly, a 200-g sample of pods is shelled to determine the proportion of shells and kernels. Then 40-50 g of kernels and 20-30 g of shells are dried for 3 hours at 130°C. The moisture content of the pods is computed from the weighted average moisture content of the two components.

For comparison, the AOCS method was tested on 200-g samples of intact pods from low-(6%) and high-(67%) moisture lots of peanuts. The average moisture content and standard deviation among 30 samples were computed, and later compared with the AOCS standard where kernels and hulls are dried separately.

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Results and Discussion

Inspection of Tables 1 and 2 indicate the following: (1) For approximately the same moisture level and peanut component, the standard deviation was about the same for Spanish- as for Virginia-type peanuts. (2) The standard deviation tended to increase with moisture content. (3) The moisture content was generally higher in hulls than in kernels. Exceptions (runs 3 in Table 1 and 4 in Tables 1 and 2) to this trend occurred because these samples had recently been dried and had not reached equilibrium while in storage prior to testing.

Table 1. Average Moisture Content and Standard Deviation Among 30 Samples of Hulls, Kernels, and Pods for Spanish Type Peanuts by Standard AOCS Method.

Run No.	Hull %MC(DB)		Kernel %MC(DB)		Pod %MC(DB)	
	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev
1	10.85	0.387	6.12	0.094	7.29	0.156
2	17.36	0.649	11.49	0.433	12.97	0.449
3	23.75	3.712	33.22	1.475	30.64	1.185
4	34.25	6.086	48.42	2.725	44.43	3.488
5	101.94	7.914	62.55	3.197	74.66	3.938

Table 2. Average Moisture Content and Standard Deviation Among 30 Samples of Hulls, Kernels, and Pods for Virginia Type Peanuts by Standard AOCS Method.

Run No.	Hull %MC(DB)		Kernel %MC(DB)		Pod %MC(DB)	
	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev
1	10.10	0.790	5.34	0.152	6.56	0.257
2	17.70	1.027	11.30	0.626	12.91	0.545
3	27.97	1.428	24.59	1.586	25.45	1.432
4	44.80	4.029	46.93	2.435	46.38	2.223
5	95.33	13.663	58.78	3.904	68.18	5.582

Analysis of variance was performed on the means and standard deviations in Tables 1 and 2 for hulls, kernels, and pods separately, using the Statistical Analysis System (SAS) (1972). No Statistical difference at the 5% level in the standard deviation was found between Spanish and Virginia-type peanuts; so the data were combined. It should be emphasized that showing no difference between peanut types does not prove that the variability was the same. It is more difficult to make a statement of this nature. Although only one peanut variety of each type was tested there is no reason to believe that the variability measured in these tests would not hold for other peanut varieties.

The increase in the standard deviation with moisture content suggested that there may be a functional relationship between the two variables. Cochran (1963) and Whitaker *et al.* (1974) reported functional relationships between the mean and variance for peanuts and other agricultural commodities. A regression analysis was performed on the combined values in Tables 1 and 2 to determine a suitable functional relationship between the standard deviation and the average moisture content for hulls, kernels, and pods. The models considered for each peanut component (hull, kernel, and pod) were polynomials of degree one and two, semi-log, and log-log. Based upon the correlation coefficient, the semi-log model appeared to provide the worst fit of measured data while differences among the linear, quadratic, and log-log models appeared to be small. The regression analysis indicated that the quadratic and higher order terms were not significant at the 5% level. Since the log-log model is slightly more complex due to log transformation, the linear model was selected to describe the functional relationship between the standard deviation and moisture content. This relationship can be written as

$$S = A * MC \tag{1}$$

where A is the regression coefficient, MC is the moisture content, and S is the standard deviation. It is assumed that all the observed variability was due to moisture content and there was no analysis error in measuring the moisture content. The model uses no intercept value since it is assumed that physically there can be no deviation among samples if they all have zero moisture content. The regression analysis provided the following equations:

$$S_H = 0.10741 \cdot MC, \tag{2}$$

$$S_K = 0.05572 \cdot MC, \tag{3}$$

and

$$S_P = 0.06239 \cdot MC, \tag{4}$$

where the subscripts H, K and P denote the standard deviations for hull, kernel and pod, respectively, and MC is the average moisture content (D.B.). Confidence limits at the 95% level were computed, using 8 degrees of freedom for the above regression coefficients for each peanut component.

$$A_H = 0.10741 \pm 0.02848, \tag{5}$$

$$A_K = 0.05572 \pm 0.00228, \tag{6}$$

and

$$A_P = 0.06239 \pm 0.01218. \tag{7}$$

Tables 1 and 2 and the regression coefficients, indicate that the variability among moisture determinations was higher for hulls than for kernels as observed by Brusewitz (1974).

Based on the variability measured in this study, the effect of number of samples on the variability among moisture determinations can be predicted for replicated samples of hulls, kernels, or pods.

Let σ be the standard deviation among N samples and σ be the standard deviation of the average of N samples. By definition,

$$\sigma_X = \sigma \,/\, (N)^{1/2}, \tag{8}$$

The standard deviation σ was chosen to be a linear function of the true moisture content μ.

$$\sigma = \alpha \cdot \mu, \quad (9)$$

where α is estimated by the appropriate value of A given in equation 5, 6, or 7. Substituting equation 9 into 8, gives

$$\sigma_{\bar{X}} = \alpha \cdot \mu \,/\, (N)^{1/2}. \quad (10)$$

By assuming that replicated samples will be distributed normally, probabilities can be determined from cumulative normal distribution tables after evaluating z as follows:

$$Z = (MC - \mu) \,/\, \sigma_{\bar{X}}. \quad (11)$$

In equation 11, the quantity (MC - μ) represents the deviation of a sample moisture content (MC) about the true lot moisture content μ and indicates the precision or error in determining the true lot moisture content. Therefore, let the deviation be expressed as:

$$D = MC - \mu. \quad (12)$$

From equation 11, the deviation can be expressed as

$$D = z \cdot \sigma_{\bar{X}}. \quad (13)$$

Substituting equation 10 into equation 13 gives

$$D = z \cdot \alpha \cdot \mu \,/\, (N)^{1/2}. \quad (14)$$

Solving for N, equation 14 becomes

$$N = z^2 \cdot \alpha^2 \cdot \mu^2 / D^2 \quad (15)$$

The term D/μ expresses the deviation as a fraction of true moisture content and can be defined as

$$E = D \,/\, \mu. \quad (16)$$

Substituting this into equation 15 results in

$$N = z^2 \cdot \alpha^2 / E^2. \quad (17)$$

The number of samples required to estimate the true moisture content with a specified precision and confidence limit for hulls, kernels, and pods can be determined by substituting into equation 17 the estimate of using the appropriate regression coefficient A. As a result, the number of samples required for hulls becomes

$$N_H = 0.011537 \quad z^2/E^2; \quad (18)$$

for kernels

$$N = 0.003105 \quad z^2/E^2; \quad (19)$$

and for pods

$$N = 0.003893 \quad z^2/E^2. \quad (20)$$

Solutions to equations 18, 19, and 20 for specific values of confidence limits and precision are given Table 3. For example, in the case of pods, Table 3 shows that to get within ± 8% of the true lot moisture content, 99% of the time, requires approximately 4 samples. This means, for example, that if the true lot moisture content of pods is 0.30 (30%), that the average of 4 samples will fall within ± .024 of 0.300 or range from 0.276 to 0.324.

The values in Table 3 show the precision of the official AOCS method for a single replicate. Using 95% confidence limits, the true moisture content would be estimated within ± 12% for pods, ± 11% for kernels, and ± 21% for hulls.

Table 3. Number of 20-g samples of hulls, 50-g samples of kernels, and 200-g samples of pods required for various values of precision and confidence levels (CL). In specifying number of samples, use the tabular value rounded up to the next whole number.

Precision	Hulls		Kernels		Pods	
E	.99CL	.95CL	.99CL	.95CL	.99CL	.95CL
0.001	76.794.3	44,320.3	20,666.2	11,927.1	25,910.1	14,953.4
0.005	3,071.8	1,772.8	836.6	477.1	1,036.4	598.1
0.010	767.9	433.2	206.7	119.3	259.1	149.5
0.020	192.0	110.8	51.7	29.8	64.8	37.4
0.030	85.3	49.2	23.0	13.2	28.8	16.6
0.040	48.0	27.7	12.9	7.4	16.2	9.4
0.060	21.3	12.3	5.7	3.3	7.2	4.2
0.080	12.0	6.9	3.2	1.9	4.0	2.3
0.100	7.7	4.4	2.1	1.2	2.6	1.5
0.120	5.3	3.1	1.4	0.9	1.8	1.0
0.140	3.9	2.3	1.0		1.3	
0.160	3.0	1.7			1.0	
0.180	2.4	1.4				
0.200	1.9	1.1				
0.250	1.2					

For comparative purposes, intact Spanish- and Virginia-type pods at two moisture levels (one high and one low) were oven dried by the same time-temperature scheme. The mean and standard deviation of the 30 samples for each moisture level and peanut type are shown in Table 4. The standard deviations appear to behave in a manner similar to that in Tables 1 and 2. The standard deviations did not differ significantly between peanut types so the data were combined to investigate the functional relationship between the mean and standard deviation. The same mathematical models used for hulls and kernels were tested on the values in Table 4. All four models had good fit with correlation coefficients of 0.99 and higher. This was because the regression was performed on only four observed points. However, the main interest was comparison of the linear model for intact pods with the linear model from the official AOCS method. The linear equation for intact pods was

$$S = 0.06936 \quad MC. \quad (21)$$

The 95% confidence limit on the regression coefficient was

$$A = 0.06936 \pm 0.01336. \quad (22)$$

The regression coefficients for intact pods (equation 22) and for the AOCS method (equation 7) were very similar but the coefficient for intact pods was slightly larger. The effect of this difference on the number of samples (N) required for

Table 4. Average Moisture Content and Standard Deviation Among 30 Samples of Unshelled Pods.

Run No.	Virginia %MC(DB)		Spanish %MC(DB)	
	Avg	Std Dev	Avg	Std Dev
1	6.39	0.254	7.33	0.330
2	68.22	4.390	75.66	5.590

a particular precision, can be determined by comparison of the values of A^2 for the two procedures. This computation, from equations 4 and 21, shows that, for the same precision, sample size needs to be 24% greater for the intact pods procedure than for the standard AOCS method of shelling the peanuts. The ranges of the confidence limits on A for the two procedures also were similar in magnitude but the range for intact pods was slightly larger.

Data from the following season supported these conclusions on intact pods. Seven groups of Spanish peanut pods varying in moisture from 8-73% produced standard deviations comparable to those of Table 4.

Because the study of intact pods was limited in the number of observations, further study would be appropriate to test the significance of the differences in results obtained by the two procedures. The AOCS standard procedure requires extra labor because peanuts must be shelled. Thus if accuracy is similar for the two procedures and only pod moisture content is needed, the procedure with intact pods would have labor saving advantages. This method, however, does not provide the moisture contents of the kernel and hull components.

In summary, the AOCS moisture determination for Spanish and Virginia peanuts was found to estimate, at the 95% CL, the true moisture within ± 12% for pods, ± 11% for kernels, and ± 21% for hulls. Data is given to estimate the sample size needed for a required precision. Moisture of whole pods can be measured to an equal precision by an abbreviated method with a slightly larger number of samples.

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