A Note on the Accuracy and Variability of Grading and Marketing High Moisture Farmer Stock Peanuts

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ABSTRACT

Previous research has shown that the farmer stock grade, lot weight, and market value could be accurately determined at kernel moisture contents greater than 10.5% without negative impact on either the producer or purchaser. In the 1998 and 1999 crop years, 686 farmer stock lots consisting of runner, virginia, and spanish types were graded and weighed at high moisture content (HMC), cured, and graded and weighed at low moisture content (LMC). The results indicated that LMC grade, lot weight, and lot value could be accurately predicted from HMC grade, lot weight, and lot value for individual farmer stock lots. However, the research did not address variability between HMC and LMC grade, weight, and values. In crop year 2001, a study was conducted in Georgia on runner-type peanuts to address variability in HMC and LMC grade, weight, and values. As farmer stock lots entered the buying point each lot was graded and weighed six times at HMC. The prediction equations estimated from the 1998 and 1999 studies were applied to the HMC values to obtain predicted grades, lot weights, and lot values. The lot was cured and graded and weighed six times at LMC and compared to the six predicted grades, lot weights, and lots values. Thirty-two farmer stock lots were included in the study. There were no significant differences in mean grade, lot weight, or lot value between the predicted and actual LMC values. Sound mature kernels and sound splits (SMKSS) differed by 0.07%. Mean lot weight differed by 7.7 kg (0.13%). Mean lot value differed by $20.11 (0.53%). Variability between predicted and actual SMKSS, lot weight, and lot value was not significantly different.

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Current marketing regulations for farmer stock (FS) peanuts require lot identity preservation until moisture content (MC) is less than 10.5% (except for seed peanuts). When MC is less than 10.5%, a sample is taken from the farmer stock lot to determine foreign material (FM), loose shelled kernels (LSK), sound mature kernels (SMK), sound splits (SS), damaged kernels (DK), and other kernels (OK). LSK, DK, and OK are inspected for *Aspergillus flavus* (Link) and if found, the value of the lot is discounted and not allowed to enter edible peanut markets. If *A. flavus* is not found, the value of the lot is determined from the grade factors and market conditions. Discounts are imposed for SS, DK, and OK exceeding 4, 1, and 4%, respectively (USDA, 2000). Dowell (1992) studied the impact of measurement error in each grade factor and demonstrated that small measurement error results in substantial impact in lot value. He concluded that 98% of lot value is determined by the SMK percentage, thus making accurate determination of SMK more important than other grade factors. Whitaker *et al.* (1991) also studied the variability associated with peanut grading, concluding that increases in sample size theoretically reduce variance and coefficient of variation, but in reality the reduction may not occur due to increased inspection error associated with larger sample size. The coefficients of variation averaged across the lots were 21.1, 18.7, 2.6, 21.2, 14.0, 55.3, and 2.4% for percentages of FM, LSK, SMK, SS, OK, DK, and gross value per ton, respectively. In another study on grade variability, similar results were found using three replicated grade samples from 14 FS lots. The coefficients of variation average across the lots were 25.0, 28.8, 2.2, 23.1, 10.8, and 45.1% for percentages of FM, LSK, SMK, SS, OK, and DK, respectively (Davidson *et al.*, 1990). In each of these studies, the lot was cured until kernel MC was less than 10.5% to remain consistent with industry standards.

The requirement to preserve lot identity until MC is less than 10.5% prevents commingling of farmer stock peanut lots prior to drying and adds handling and drying cost that could be minimized by using more efficient, larger batch drying equipment. At the request of the U.S. peanut industry, a study was conducted in crop years 1998 and 1999 to examine the relationship between high moisture content (HMC) ($10.5 \leq MC < 25$) and low moisture content (LMC) ($MC < 10.5$) farmer stock grades, net lot weight (LW), and lot value (LV). Blankenship *et al.* (2001) graded 686 farmer stock lots at HMC, dried the lots to less than 10.5% MC, and then graded the lots at LMC. The objective of their research was to develop mathematical relationships between HMC and LMC farmer stock grade factors, LW, and LV. Linear regression equations were derived from the HMC and LMC data and equations were estimated for each FS grade factor, LW, and LV. The actual LMC FS grade factor, LW, and LV were used as dependent variables and the HMC grade factors, LW, and LV along with HMC kernel moisture content were used as independent variables. The resulting prediction equations allowed HMC grade factors, LW, and LV to predict LMC grade factors, LW, and LV to be predicted from the HMC grade samples. For runner type peanuts, the regression coefficients for SMKSS, LW, and LV were 0.880, 0.998, and 0.997, respectively (Blankenship *et al.*, 2001). Their predictions were within standard errors ($P = 0.05$) of the actual LMC grade factors, LW, and LV and they concluded that, on average, HMC grading will not significantly affect peanut marketing. Their data consisted of one observation for each grade factor, weight, and value taken at high and low moisture content for each farmer stock lot which represented a multi-factor experiment with single measurements. This approach was consistent with current industry practices because time constraints at peanut harvest and marketing limit grading of individual farmer stock lots to one official grade per lot. However, the data did not allow analysis of variability within individual FS lots when graded and marketed and high and low moisture contents.

To improve handling and curing efficiency, the peanut industry has expressed interest in changing regulations to allow grading FS peanuts at MC greater than 10.49%. However, to ensure equity in marketing, the accuracy and variability of the predicted FS grade factors, LW, and LV must be statistically similar to those resulting from FS grading under current regulations. The objectives of this research were to utilize the equations estimated in previous research to (a) determine and compare the mean and variability of FS grade factors, LW, and LV associated with HMC and LMC grading, and (b) determine if HMC grading impacts the distribution of FS grade factors, LW, and LV compared to LMC grading.

Materials and Methods

Thirty-two runner type farmer stock lots were evaluated during the 2001 harvest season. Farmer stock lots were delivered to the buying point and incoming moisture content was determined. If moisture content of the lot was between 10.5 and 25%, the lot was utilized in the study. FS lots with MC greater than 25% were omitted because electronic moisture meters currently used in the industry are not accurate at these levels (Blankenship *et al.*, 2001). To examine the impact of high moisture grading on the variability of farmer stock grades, net lot weight, and lot value repeated measurements for each farmer stock lot were required at high and low moisture contents which represents a multi-factor experiment with repeated measurements. Each lot was graded and weighed six times at high moisture content using standard Federal State Inspection Service (FSIS) grading procedures (USDA, 2000). The prediction equations estimated in the 1998 and 1999 project were then used to obtain predicted LMC grade factors, LW, and LV for each grade replication as well as mean and variance data. The lot was then dried to less than 10.5% moisture using commercial drying equipment at the cooperating buying points and graded and weighed six times by the same FSIS inspectors using standard FSIS grading procedures. The predicted LMC grade factors, net lot weights, and lot values were compared to the actual LMC factors.

Three comparisons (COMP) were analyzed including:

COMP1: 1st HMC grade factors, LW, and LV versus 1st LMC grade factors, LW, and LV for each FS lot,

COMP2: Mean of the six HMC grade factors, LW, and LV versus the mean of the six LMC grade factors, LW, and LV, and

COMP3: 1st HMC grade factors, LW, and LV versus the mean of the six LMC grade factors, LW and LV.

If FS peanut grade regulations were changed to allow FS grading at MC greater than10.49%, COMP1 would represent the single official FS grade determining grade factors, lot weight, and lot value. COMP1 is important to the U.S. peanut industry because bias in the mean across FS lots would affect the overall dollar value of farmer stock peanuts and impact the profitability to farmers, buying points, and shellers. COMP2 better represents the true means of the grade factors, LW, and LV at HMC and LMC. COMP2 also allows analysis of the total variability within individual FS lots when graded at high and low MC. Total variability was defined to consist of sampling variance and measurement variance. Dowell (1992) concluded that 24% of the total error in peanut grading was attributable to equipment and human error, but changes in the grading system would have varying impact on the variability related to FS grade factors. COMP2 will not address the components of variability but instead determines if significant differences exist in the mean and total variability associated with FS grades, LW, and LV resulting from HMC and LMC grading. COMP3 compares the 1st HMC grade factors, LW, and LV and the means of the six LMC samples. COMP3 is an important comparison because assuming that the mean of the six LMC samples better represents the actual lot composition, time and labor constraints during harvest prohibit multiple grade samples per FS lots. Differences in means of the grade factors, LW, and LV from each comparison were separated using Fisher's t-test ($P = 0.05$).

In addition, the farmer stock grade, net lot weight, and lot value distributions were analyzed. The hypothesis tested was that the 1st HMC grade resulted in a frequency distribution of grade factors, lot weight, and lot value that was different from the 1st LMC grade. Means and standard deviations for grade factors, lot weight, and lot value were calculated from samples 2 through 5 at low moisture. In this analysis the 1st HMC and LMC sample was omitted to prevent bias in the results. The distributions were generated from the number of times that the 1st HMC and

1st LMC factors were within ±1/2 standard deviations of the LMC mean of samples 2 through 5. The Shapiro-Wilk test was used to test the null hypothesis that the data values did not significantly differ from normally distributed data.

Results and Discussion

No significant differences resulted between the predicted and actual mean farmer stock grade factors, LW, and LV comparing the mean values of the 1st HMC and 1st LMC samples (COMP1). FM, LSK, SMKSS, OK, LW, and LV differed by 0.65%, 0.05%, 0.17%, 0.29%, 7.3 kg, and $9.08, respectively, between the 1st HMC and 1st LMC samples. No statistical differences (P = 0.05) resulted in the mean FS grades, LW, and LV. In the HMC samples, the coefficients of variation averaged across all lots were 48.1, 37.3, 4.8, 40.1, 36.9, and 36.7% for %FM, %LSK, %SMKSS, %OK, LW, and LV, respectively. In the LMC samples, the coefficients of variation averaged across all lots were 54.9, 39.3, 4.1, 28.5, 37.5, and 37.7% for %FM, %LSK, %SMKSS, %OK, LW, and LV, respectively. In COMP1, the differences in the HMC and LMC coefficients of variation were not statistically different (P = 0.05) for the FS grade factors, LW, and LV as determined by Fisher's t-test. Thus, grading FS peanuts on a HMC basis did not significantly change means or add variation to the grading and value determination process in COMP1 (Table 1 contains results for SMKSS, LW, and LV).

No significant differences resulted between the pre-

Table 1. Sound mature kernels and sound splits (SMK + SS), net lot weight, and lot value resulting from the 1st grade sampling and the mean and coefficient of variation resulting from six high moisture content and low moisture content grade samples from 32 farmer stock lots.

		SMK + SS			Net lot weight			Lot value		
		1st Sample	6 Samples		1st Sample	6 Samples		1st Sample	6 Samples	
FS lot	Method	mean		CV	mean		CV	mean		CV
		%	%	%	kg	kg	%	$	$	%
1	HMC[a]	73.5	73.3	1.1	4,464	4,417	0.88	3,117	3,049	1.98
	LMC	73.0	73.5	1.4	4,439	4,410	0.59	3,076	3,060	1.58
2	HMC	75.3	75.3	1.08	4,581	4,538	0.76	3,278	3,185	1.17
	LMC	73.0	75.0	1.18	4,564	4,584	0.66	3,198	3,254	1.04
3	HMC	74.2	74.5	1.64	3,999	3,964	0.51	2,805	2,797	1.43
	LMC	74.0	75.0	0.94	3,972	3,950	0.89	2,769	2,814	1.25
4	HMC	76.0	74.3	1.63	3,873	3,870	0.46	2,723	2,723	1.56
	LMC	73.0	73.8	1.81	3,880	3,895	0.44	2,712	2,717	2.01
5	HMC	72.0	75.6	1.83	5,494	5,482	0.49	3,714	3,864	1.93
	LMC	74.0	74.6	1.38	5,483	5,495	0.54	3,838	3,896	1.91
6	HMC	74.0	74.3	1.09	2,359	2,375	0.78	1,634	1,649	1.65
	LMC	74.0	74.0	1.91	2,339	2,336	0.99	1,620	1,621	2.02
7	HMC	76.5	76.3	0.71	1,307	1,314	0.42	937	939	1.05
	LMC	76.0	76.5	0.67	1,275	1,286	0.98	890	904	2.05
8	HMC	72.7	73.5	1.67	2,461	2,464	0.15	1,713	1,704	1.71
	LMC	72.0	72.7	2.25	2,414	2,445	0.83	1,622	1,661	3.26
9	HMC	76.0	76.3	1.36	8,583	8,656	0.53	6,003	6,114	1.06
	LMC	76.0	75.7	0.67	8,593	8,640	0.81	5,931	6,037	1.56
10	HMC	72.0	75.2	1.01	8,470	8,733	2.83	5,699	6,147	5.05
	LMC	75.0	75.2	2.95	8,524	8,813	2.61	5,897	6,162	3.47
11	HMC	76.0	75.7	0.68	3,526	3,581	0.94	2,508	2,534	1.51
	LMC	76.0	75.7	1.36	3,543	3,568	0.41	2,499	2,535	1.12
12	HMC	75.7	75.7	1.08	3,919	3,871	1.35	2,794	2,745	2.18
	LMC	76.0	76.0	0.83	3,824	3,844	0.26	2,721	2,744	1.13
13	HMC	76.0	75.3	0.73	3,849	3,880	0.95	2,744	2,741	1.15
	LMC	75.0	75.5	0.69	3,915	3,880	0.57	2,777	2,764	0.89

14	HMC	74.0	74.5	1.36	3,835	3,888	1.28	2,648	2,713	2.02
	LMC	77.0	75.7	1.40	3,890	3,885	1.12	2,798	2,762	1.45
15	HMC	72.0	69.5	2.98	3,104	3,129	2.36	2,059	2,006	4.65
	LMC	72.0	71.0	1.26	3,139	3,109	1.44	2,082	2,036	2.48
16	HMC	62.0	64.5	2.19	4,422	4,418	1.29	2,600	2,706	3.22
	LMC	67.0	67.2	2.64	4,647	4,403	4.99	2,893	2,779	3.56
17	HMC	70.0	70.6	2.13	4,528	4,503	0.57	2,991	2,997	2.47
	LMC	74.0	73.2	1.82	4,379	4,488	2.51	2,915	3,095	3.48
18	HMC	65.0	64.5	1.89	5,032	5,116	7.01	3,106	3,134	8.38
	LMC	65.0	64.0	3.42	4,836	4,969	8.56	2,984	3,021	10.20
19	HMC	66.0	67.8	2.54	6,382	6,242	1.20	3,985	4,032	1.52
	LMC	65.0	67.3	3.47	6,443	6,328	0.98	3,900	4,004	3.08
20	HMC	76.0	74.8	1.56	3,961	3,959	0.85	2,817	2,755	1.28
	LMC	72.0	73.2	2.01	4,220	4,082	3.54	2,798	2,751	3.24
21	HMC	77.0	75.5	1.38	4,239	4,279	2.67	3,043	3,027	2.76
	LMC	74.0	74.5	0.98	4,067	4,312	4.58	2,753	2,972	5.48
22	HMC	70.0	70.8	1.18	6,194	6,444	2.74	4,037	4,284	4.67
	LMC	71.0	70.5	2.43	6,450	6,434	0.52	4,289	4,260	1.14
23	HMC	73.0	72.5	1.44	6,259	6,247	1.01	4,297	4,250	1.69
	LMC	70.0	70.7	1.46	6,226	6,181	0.51	4,093	4,092	1.26
24	HMC	72.0	72.3	2.08	6,119	6,225	1.83	4,230	4,219	3.23
	LMC	70.0	69.2	1.42	6,305	6,274	0.85	4,143	4,076	1.05
25	HMC	71.0	71.1	1.05	6,099	6,051	1.48	4,028	4,032	2.23
	LMC	70.0	70.5	1.59	6,180	6,210	0.68	4,028	4,046	1.23
26	HMC	74.0	74.8	1.00	5,423	5,444	0.97	3,703	3,756	1.80
	LMC	74.0	73.5	0.78	5,381	5,402	0.91	3,596	3,622	1.76
27	HMC	74.0	72.2	1.88	5,943	6,002	0.76	4,106	4,056	1.96
	LMC	71.0	72.3	2.04	5,910	5,922	0.56	3,850	3,955	1.81
28	HMC	74.0	74.5	0.73	6,496	6,497	0.78	4,537	4,560	0.87
	LMC	75.0	75.2	1.00	6,433	6,410	0.68	4,514	4,497	1.29
29	HMC	76.0	74.6	1.83	6,516	6,426	0.84	4,635	4,478	2.24
	LMC	75.0	74.3	0.81	6,337	6,363	0.82	4,485	4,446	1.55
30	HMC	70.0	70.7	3.13	1,790	1,817	1.29	1,172	1,202	2.33
	LMC	72.0	71.2	1.46	1,688	1,685	0.62	1,132	1,122	2.77
31	HMC	73.0	72.2	1.62	2,841	2,916	3.46	1,950	1,978	4.28
	LMC	76.0	72.2	3.21	2,938	2,915	0.98	2,077	1,971	3.53
32	HMC	72.0	72.6	1.42	3,977	3,982	1.49	2,671	2,692	2.86
	LMC	73.0	73.7	1.10	3,931	3,933	1.35	2,702	2,719	2.45
AVG	HMC	72.98	72.95	4.38	4,688	4,699	36.91	3,192	3,219	37.77
	LMC	72.81	72.88	4.31	4,699	4,691	37.10	3,201	3,199	37.17
CV	HMC	4.76			36.85			36.69		
	LMC	4.07			37.53			37.68		

[a]HMC = High moisture content; LMC = Low moisture content.

dicted and actual mean farmer stock grade factors, LW, and LV by comparing the mean values of the six HMC and six LMC samples (COMP2). FM, LSK, SMKSS, OK, LW, and LV differed by 0.19%, 0.13%, 0.07%, 0.21%, 7.7 kg, and $20.11, respectively. No statistical differences (P = 0.05) were observed when the mean FS grades, LW, and LV were averaged across samples. In the HMC samples, the coefficients of variation averaged across all lots were 49.3, 36.9, 4.4, 32.7, 36.4, and 37.8% for %FM, %LSK, %SMKSS, %OK, LW, and LV, respectively. In the LMC samples, the coefficients of variation averaged across all lots were 54.9, 38.9, 4.3, 34.3, 37.1, and 37.1% for %FM, %LSK, %SMKSS, %OK, LW, and LV, respectively. In COMP2, the differences in the HMC and LMC coefficients of variation were not statistically different (P = 0.05) for the FS grade factors, LW, and LV (Table 1 contains results for SMKSS, LW, and LV).

No significant differences resulted by comparing the 1st HMC grade factors, LW, and LV with the six LMC samples (COMP3). Mean differences of 0.47%, 0.07%, 0.10%, 0.08%, 3.6 kg, and $7.15 resulted for %FM, %LSK, %SMKSS, %OK, LW, and LV, respectively (Tables 1 and 2).

Table 2. Mean difference and coefficient of variation for peanut grade factors, lot weight, and lot value between the 1st HMC grade and the six LMC grades.

Item	Mean difference[b]
FM	0.47 %
LSK	0.07 %
SMKSS	0.10 %
OK	0.08 %
Lot weight	3.60 kg
Lot value	$7.15

[a]FM = Foreign material, LSK = loose shelled kernels, SMKSS = sound mature kernels and sound splits, OK = other kernels.

[b]No differences at (P ≤ 0.05).

The cumulative distributions for SMKSS of the number of times HMC and LMC factors were within ±1/2 standard deviations of the LMC means are illustrated in Figure 1a. The Shapiro-Wilk test W statistic which determines if a distribution significantly differs from normal distributions was 0.789 (Pr < W = 0.015) for the 1st LMC SMKSS differences and 0.731 (Pr < W = 0.033) for the 1st HMC SMKSS differences. A similar comparison for the HMC and LMC distributions of LW showed that the Shapiro-Wilk W statistic was 0.801 (Pr < W = 0.021) for the 1st LMC LW differences and 0.830 (Pr < W = 0.041) for the 1st HMC LW differences (Fig. 1b). The HMC and LMC cumulative distributions for LV as shown by the Shapiro-Wilk W statistic was 0.723 (Pr < W = 0.034) for the 1st LMC LV differences and 0.752 (Pr < W = 0.016) for the 1st HMC LV differences (Fig. 1c). None of the distributions significantly differed from normal (Fig. 1a, b, c).

In summary, the results from this project support previous results (Blankenship *et al.* 2001) which showed no significant differences in mean FS grade factors, LW, and LV. Thus, on average, the value of FS peanuts will not be impacted by changing regulations allowing FS grading at MC greater than 10.49%. Coefficients of variation confirmed that the variability associated with FS grading at HMC was not significantly different than variability resulting at LMC. This result, coupled with no significant mean differences, implies that confidence in resulting the HMC grades, LW, and LV should be the same as in LMC results for individual FS lots.

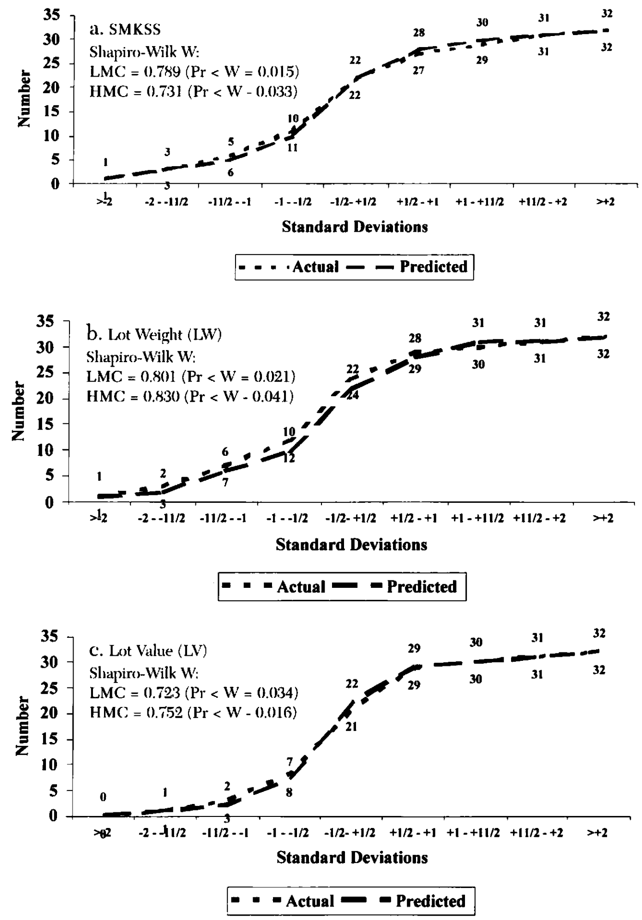

Fig. 1. Cumulative distributions generated from the number of times that the 1st HMC and 1st LMC factors were within ± 1/2 standard deviations of the LMC mean from 32 farmer stock lots, 2001.

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