Comparison of Pneumatic and Automatic Spout Samplers to Determine Grade of Farmers Stock Peanuts

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ABSTRACT

There were significant differences in performance of the pneumatic sampler (PS) and automatic spout sampler (ASpS) as determined by differences in mean values or variability for several grade factors. Significant differences in mean were found for loose shelled kernels (LSK), foreign material (FM), sound mature kernels (SMK) and other kernels (OK). Significant differences in variability were also found for LSK, sound mature kernels plus sound splits (SMK+SS) and total kernels (TK). The mean LSK averaged 1.6 percentage points higher for samples taken with the PS than for those taken with the ASpS. Evidently the PS shelled out a small percentage of the peanuts during the sampling process. This shelling action of the PS may have contributed to the slightly higher estimations of foreign material (FM) and other kernels (OK) and the slightly lower estimation of total sound mature kernels (SMK+SS) than obtained with the ASpS. When applying 1988 quota prices to the average grade for these 14 loads of peanuts, the value for 0.90 metric ton (1 ton) of peanuts was $18.60 higher for peanuts using the ASpS compared to the same amount using the PS. This higher value would be an important factor when considering new marketing strategies that use the ASpS or similar in-line samplers. When using the PS and AsPs, the grade (except for SMK) tended to overestimate the plant outturns. Linear regression equations were developed to relate grade estimates to plant outturns.

Key Words: Farmers stock grade, peanut sampling, peanut grading, peanut shelling outturns, peanut marketing systems, peanut marketing strategies.

The peanut industry (11) has identified an immediate need to improve sampling, grading and marketing of farmers stock (FS) peanuts to provide opportunities for reducing aflatoxin and foreign material and for minimizing the occurrence of other quality problems. A study was designed in 1986 to use 14 loads of CY 1986 Florunner FS peanuts to determine the accuracy and variability of the current farmers stock grading system and to evaluate certain potential improvements to this system.

Three manuscripts have been prepared to present the results of this study. One manuscript (8) provides information on the accuracy and variability of the current system. Another manuscript (9) provides information on the comparison of the current visual method with an ELISA method for detection of aflatoxin contaminated loads of FS peanuts. This manuscript presents information on the comparison of the currently used pneumatic sampler (PS)(2) with an automatic spout sampler (ASpS)(5). The PS takes samples from static loads of FS peanuts by vertically probing the load pneumatically in several locations to obtain a 10 cm diameter core of material in each location. The sampler blends the material and subdivides the sample to provide a subsample for grading. The advantage of the PS is that the peanuts do not have to be dumped or handled to obtain a sample. The disadvantages of the PS is that the probe and transporting air imparts mechanical damage to the peanuts; it may not probe representative locations of non-homogenous loads; and it is not suitable for proposed new marketing strategies (7) that require in-line samplers. The ASpS is an in-line sampler that takes a sample by a spout moving periodically across a flowing (dynamic) stream of peanuts as the peanuts are handled by an elevator and conveyer system. The advantages of the ASpS are that it imparts an insignificant amount of damage and it provides a representative sample even on non-homogenous loads. The disadvantages of the ASpS is that it requires handling of the load of peanuts through an elevator facility. Except for a comparison (2) made over 25 years ago for the foreign material (FM) and loose shelled kernels (LSK) grade factors, the literature does not report any data to compare the performance of the PS and AspS in sampling FS peanuts. Such data is needed to evaluate potential improvements in the sampling, grading and marketing of FS peanuts, especially where an in-line sampler is required. In addition, data is needed to relate the grade determinations (from subsamples taken with the two samplers) to the commercial outturns. Thus, the objective of this manuscript is to provide comparative performance data for the PS and the ASpS and to relate this data to pilot plant outturns and economic value.

Materials and Methods

A detailed description of the current grading procedures and requirements for FS peanuts are available from the USDA (10). Description of the PS (2), the sheller and presizer (3), and other grading equipment (4) are available. The PS is used to probe a static load of FS peanuts in drying wagons to obtain approximately 20 kg of peanuts. The sample is passed through a device that splits out a 4 kg portion and returns 16 kg of peanuts to the load. The 4 kg portion is then divided into a 2 kg (~1800 gram) grade sample and a 2 kg check sample. The check sample is stored and not used unless a regrade or official verification of the grade is needed. The percent foreign material (FM), percent loose shelled kernels (LSK) and the presence of kernels with Aspergillus flavus are determined from the 1800 g sample. Other grade factors, such as percentages of sound mature kernels (SMK), sound split kernels (SS), other kernels (OK), damaged kernels (DK) and total kernels (TK), are determined from shelling a 500 gram portion of clean pods taken from the 2 kg grade sample. Kernels from the 500 gram sample of pods are also visually inspected for presence of *A. flavus*. If one or more *A. flavus* kernels are found in LSK and the 500 g portion, the load is designated Segregation 3.

One load of Florunner FS Peanuts (~3632 kg) were obtained from each of 14 commercial fields in Southwest Georgia. From each of the 14 loads, three, 20 kg parcels were removed by Federal State Inspection Service (FSIS) using the PS and Official Probe Patterns 3, 5 and 10. One 60-kg parcel was taken with the ASpS as the peanuts were loaded into the USDA pilot shelling plant. Each 60-kg parcel was divided into 3, 20-kg parcels by the official farmers stock divider (dividing 60 kg to 4, 15 kg samples and then recombining two of the 15 kg samples and dividing out 3.7 and 1.4 samples to add to each of the two other 15 kg samples). The physical layout of the pilot plant did not permit installation of three ASpS to take 3, 20-kg parcels. Each 20 kg parcel was then subdivided by the official grade farmers stock divider into approximately 10, 2 kg samples providing from each load approximately 30, 2 kg grade samples for each sampling method (total ≈420 grade samples for PS and ≈420 grade samples for ASpS). The

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subsamples were coded and graded by licensed FSIS inspectors. After sampling, each of the 14 loads was shelled in the USDA pilot shelling plant that has the same process operations and shelling equipment as that used in commercial shelling plants (1). Grade data from the ASpS was compared to the PS by ANOVA and sign test, and then the grade estimates for both PS and ASpS were compared to the pilot shelling plant outturns by simple linear regression.

Aflatoxin was determined for each load by putting all shelled peanuts for each market grade of each load through a 4-way divider until a 40 kg subsample was obtained. Each 40 kg shelled subsample was put through the official grade shelled stock divider to divide our 40, 1 kg samples of edible shelled peanuts for each market category (i.e. jumbo, medium, No. 1, and splits), comminuting each sample in a Dickens mill (without subsample dividers)(5) and supplying all 40, 1 kg samples of meal from each market category to the official AMS Laboratory in Albany, GA for standard (TLC) aflatoxin determinations. Weighted mean aflatoxin (AF) for each load was calculated by $AF = (A_1W_1+A_2W_2 \circ +A_nW_n)/(W_1+W_2 \circ +W_n)$ where Wi and Ai represent the shelling outturn weight and the mean average aflatoxin contamination (ppb) of each category, respectively. The percent of Segregation 3 samples for each load was calculated and compared to aflatoxin for each load. This comparison indicated the comparative effectiveness of the two samplers in identifying Segregation 3 loads.

Results

An analysis of variance by Tsai *et al.* (8) showed that there were no differences in means or variability of grade factors obtained with samples taken with the three probe patterns thus the grade data from the 30 subsamples from the PS were compared with the grade data from the 30 ASpS subsamples. Means and variances among the 30, 1800 g grade samples and the corresponding pilot plant outturns are presented in Table 1 for each of the 14 loads. Similar results for grade factors determined from the 500 g sample are presented in Tables 2 and 3. The means and variances from the PS and ASpS methods were compared using the sign test. From 14 loads, the differences are statistically significant (at the 5.8% level) if there are 3 or less signs of the same kind among the 14 comparisons. For FM, for example, the differences between the means (PS-ASpS) gave 13 +'s and 1 - giving a score of 0.5 to each sign when the difference is 0. Besides FM, the PS and ASpS gave statistically significantly different means for LSK, SMK, and OK. In terms of variability, the samples differed for LSK, SMK+SS and TK. FM, LSK, and OK were generally higher and SMK lower for samples taken by PS than for those taken by ASpS. Variances were generally higher for the higher means. These differences in means and variability are probably associated with the difference in mechanical damage imparted by the samplers as discussed below. Using average grade values for these 14 loads and 1988 prices (Peanut Quota Loan Pricing Schedule) and ignoring differences in percent of Seg. 3 samples, the grades from samples taken with the ASpS provided a \$20.67 higher market value per metric ton (\$18.60 short ton) than that obtained with grades from the samples taken with the PS. The performance of PS and ASpS were about the same in sampling for visible *A. flavus* kernels showing 67-100% of grade samples had one or more *A. flavus* kernels in the two loads that had more than 20 ppb aflatoxin.

As each load of peanuts was processed in the pilot shelling

Table 1. Performance of pneumatic sampler (PS) and automatic spout sampler (ASpS) when using 1.8 kg subsamples to determine percentage of FM, LSK and Segregation 3 samples.

	Foreign material (FM)					Loose shelled kernels (LSK)					% Seq. III & aflatoxin		
	Pneumatic		Spout			Pneumatic		Spout			Pneu.	Spout	
Load Number	Mean	Variance	Mean	Variance	Plant Outturns	Mean	Variance	Mean	Variance	Plant Outturns	Mean[1]	Mean[1]	Plant Outturns[2]
1	4.0	0.72	3.2	0.46	2.6	2.8	0.83	1.2	0.17	1.0	0	0	0
2	2.0	0.47	2.0	0.64	1.7	2.5	0.99	1.7	0.50	1.5	0	0	0
3	3.3	0.36	3.0	0.60	2.9	4.5	1.79	2.3	0.60	2.5	0	0	0
4	3.1	0.62	2.5	0.40	2.9	4.4	1.23	3.4	0.87	1.7	3.3	0	0.9
5	3.4	0.63	3.4	3.07	2.5	3.5	0.74	3.0	0.46	1.9	0	0	0.2
6	3.8	1.77	2.8	0.18	2.9	2.5	1.00	1.0	0.07	3.1	0	0	0
7	4.8	0.31	4.5	0.68	4.3	7.0	2.22	3.1	1.19	2.9	6.7	3.3	0.4
8	2.7	0.59	2.5	1.25	2.5	3.1	0.42	2.4	0.31	2.1	0	0	0
9	3.9	0.98	2.9	0.35	2.5	4.6	1.03	2.1	0.54	2.0	61.9	36.7	13.9
10	3.6	0.92	3.0	0.24	2.4	4.3	1.00	2.0	0.43	1.8	100.0	80.0	18.8
11	4.7	1.95	3.9	1.23	5.1	5.0	1.96	3.9	0.60	3.1	0	0	0.2
12	4.9	1.11	4.2	0.75	4.9	5.9	3.13	3.3	0.98	3.6	71.4	66.7	93.6
13	2.5	0.21	2.3	0.25	1.7	3.9	1.51	3.5	1.69	2.8	100.0	83.3	130.0
14	7.4	2.70	6.7	4.60	4.1	3.4	1.57	2.1	0.86	2.1	33.3	50.0	9.6
Avg.[3]	3.9a	0.95a	3.4b	1.05a	3.1c	4.1a	1.39a	2.5b	0.66b	2.3c	26.9a	22.9a	19.1a

[1]Percentage of grade samples identified as having visible *A. flavus* kernels (Seg. III).

[2]Aflatoxin contamination (ppb) that was found in the edible market grades of shelled peanuts processed by the pilot shelling plant.

[3]The same letter(s) by respective means and variances indicate that comparable values are not significantly different. Means and variances for the pneumatic and spout samplers are for ≈30 subsamples and averages are for ≈420 subsamples.

plant, the major types of foreign material were separated by the precleaner. The materials were weighed and the percentages in each load were calculated and presented in Table 4. A linear regression of the difference in the estimated and actual FM on the percent of each type indicated that within the range investigated, the performance of the PS or ASpS was not significantly affected by the types and amounts of foreign material within the FS peanuts.

Table 2. Performance of pneumatic sampler (PS) and automatic spout sampler (ASpS) when using 500 g subsamples to determine percentage of edible peanuts.

	Sound mature kernels (SMK)					Sound splits (SS)					Sound mature kernels plus sound splits (SMK+SS)				
	Pneumatic		Spout			Pneumatic		Spout			Pneumatic		Spout		
Load #	Mean	Var.	Mean	Var.	Plant Outturns	Mean	Var.	Mean	Var.	Plant Outturns	Mean	Var.	Mean	Var.	Plant Outturns
1	58.4	1.96	59.5	3.74	56.6	1.3	0.36	1.2	0.27	5.1	59.8	2.16	60.7	4.37	61.7
2	67.1	3.57	67.1	3.78	62.9	3.3	0.94	3.1	0.94	6.1	70.3	2.07	70.2	2.64	69.0
3	64.6	1.78	64.7	3.07	59.6	4.6	0.93	4.9	0.59	9.6	69.2	1.16	69.7	2.62	69.2
4	66.4	2.81	66.8	1.97	63.1	5.7	1.78	5.9	1.52	9.5	72.1	1.31	72.7	0.86	72.6
5	70.4	1.11	70.4	1.34	66.0	3.6	0.63	3.7	0.55	4.5	73.9	0.51	74.1	0.55	70.5
6	60.1	1.48	61.1	2.57	56.3	1.8	0.36	1.8	0.39	5.3	61.9	1.78	62.9	2.14	61.6
7	63.8	3.09	65.4	2.20	57.3	5.8	1.32	4.4	0.59	9.8	69.6	1.68	69.8	1.93	67.1
8	66.6	1.45	68.0	1.45	65.9	6.2	1.00	5.5	0.91	7.6	72.8	0.49	73.4	0.51	73.5
9	62.6	0.96	62.7	1.88	53.2	4.8	0.78	4.3	0.72	9.2	67.5	1.01	66.9	1.26	62.4
10	64.8	2.17	65.1	1.59	57.6	3.6	0.37	3.3	0.52	8.0	68.4	1.97	68.4	1.30	65.6
11	63.5	2.08	65.0	4.96	57.0	9.3	2.94	8.1	5.12	14.5	72.8	1.66	73.1	0.67	71.5
12	58.1	2.47	58.9	2.38	57.9	1.7	0.13	1.8	0.16	7.6	59.8	2.16	60.7	2.38	65.5
13	69.9	0.99	70.3	1.33	67.0	2.6	0.61	2.8	0.59	6.8	72.6	0.55	73.1	0.64	73.8
14	47.4	1.88	47.6	2.03	44.0	2.5	0.49	2.6	0.35	5.3	49.9	1.58	50.2	2.19	49.3
Avg.[1]	63.1a	1.85a	63.8b	2.45b	58.9c	4.1a	0.90a	3.8a	0.94a	7.8b	67.2a	1.44a	67.6b	1.72b	66.7a

[1]The same letter(s) by means and variances indicate that comparable values are not significantly different.

Table 3. Performance of pneumatic sampler (PS) and automatic spout sampler (ASpS) when using 500 g subsamples to determine percentage of non-edible and total peanut kernels.

	Other kernels (OK)					Damaged kernels (DK)					Total kernels (TK)				
	Pneumatic		Spout			Pneumatic		Spout			Pneumatic		Spout		
Load #	Mean	Var.	Mean	Var.	Plant Outturns	Mean	Var.	Mean	Var.	Plant Outturns	Mean	Var.	Mean	Var.	Plant Outturns
1	12.3	1.27	11.8	1.78	8.5	1.1	.17	0.9	.16	0.7	73.2	.29	73.4	.55	70.2
2	7.6	1.38	7.3	1.56	5.3	0.5	.11	0.7	.10	0.3	78.4	.31	78.3	.20	74.3
3	7.9	.87	7.6	.97	6.0	1.3	.13	1.3	.26	0.6	78.4	.10	78.6	.27	75.2
4	5.6	.73	5.2	.39	3.7	0.7	.14	0.7	.25	0.4	78.4	.16	78.6	.16	76.3
5	3.6	.29	3.7	.41	2.9	0.4	.08	0.4	.07	0.3	78.0	.14	78.2	.36	73.4
6	12.1	.91	11.4	.96	7.6	0.4	.08	0.4	.07	0.2	74.4	.25	74.7	.29	69.2
7	7.0	.81	6.7	.99	6.6	0.8	.07	1.0	.11	0.5	77.5	.27	77.5	.33	73.7
8	4.9	.36	4.3	.26	3.6	0.3	.04	0.4	.05	0.3	77.9	.10	78.2	.18	77.1
9	7.0	.33	7.3	.96	5.9	0.8	.12	0.9	.06	0.6	75.2	.19	75.1	.24	68.3
10	6.1	1.12	6.1	1.09	5.4	0.7	.12	0.8	.15	0.5	75.2	.70	75.4	.77	71.0
11	4.4	.50	4.5	.47	3.6	1.9	.30	0.7	.13	0.7	78.1	.17	78.3	.20	75.1
12	15.9	1.61	15.0	1.57	12.2	1.2	.15	1.2	.13	0.8	76.9	.15	76.8	.24	77.7
13	3.5	.17	3.3	.25	2.8	0.7	.09	0.7	.11	0.4	76.8	.15	77.1	.20	76.6
14	16.6	.62	16.4	.78	14.1	1.3	.21	1.4	.14	0.6	67.8	.59	67.9	.60	63.4
Avg.[1]	8.2a	0.78a	7.9b	0.89a	6.3c	0.8a	.13a	0.8a	.13a	0.5b	76.2a	.26a	76.3a	.33b	73.0b

[1]The same letter(s) by means and variances indicate that comparable values are not significantly different.

Table 4. Types and amounts of foreign material (FM) in 14 loads of Florunner farmers stock peanuts.

Load Number	Average FM %	FM Type and composition (%) Rocks	Dirt	Sticks	Light Trash
1	2.56	0.09	0.51	1.16	0.80
2	1.74	0.15	0.33	0.86	0.41
3	2.85	0.24	0.44	1.42	0.75
4	2.87	0.55	1.59	0.38	0.35
5	2.53	0.80	1.30	0.14	0.29
6	2.85	0.18	0.72	1.32	0.64
7	4.31	0.19	0.44	2.91	0.77
8	2.51	0.50	0.82	0.79	0.41
9	2.47	0.22	0.58	0.77	0.90
10	2.40	0.16	0.55	0.63	1.06
11	5.05	1.39	2.80	0.42	0.43
12	4.86	0.24	0.88	2.54	1.21
13	1.67	0.06	0.47	0.41	0.74
14	4.14	1.10	2.11	0.28	0.65
Means	3.06	0.42	0.97	1.00	0.66

Except for SS, the mean grade (on the average) overestimated the outturns for both the PS and ASpS. Linear regression equations were developed to relate grade predictions to plant outturns for both the PS and ASpS. The regression and correlation coefficients are presented in Table 5. Correlation coefficients were highest for OK and SMK+SS and lowest for LSK and FM. The slopes were high and intercepts small for most grade factors indicating a high degree of linearity. The intercepts for SMK and TK were larger than expected and may be related to difference in shelling actions between the grade and commercial type shellers.

Discussion

As indicated by Dickens (2) in the 1960-61 tests, the higher estimates of LSK obtained when using the PS resulted from the shelling of small percentage of peanuts by the probe-type sampler. In the 1960-61 tests the percent of LSK of runner-type peanuts for the PS and ASpS was 2.96 and 2.21, respectively, as compared to 4.1 and 2.5, respectively, in this study. Thus the PS increased the LSK by 34 and 64 percent for the earlier and later studies, respectively. Some of the difference in LSK for the two studies may be related to the difference in varieties as the earlier runner varieties had thicker hulls than the currently used Florunner variety. Shelling action by the PS would also produce a small percentage of mechanical damage and hulls that would tend to provide slightly higher estimates of foreign material and SS. The shelling action by the PS tended to promote slightly higher estimates of LSK, FM, and OK and lower estimates of SMK+SS and TK. In the 1960-61 tests the percent of FM of runner-type peanuts for the PS and ASpS was 2.64 and 2.60, respectively, as compared to 3.9 and 3.4, respectively, in this study. Thus the PS provided a 2 and 15 percent higher estimate of foreign material than the ASpS for the earlier and later studies, respectively. Our harvesting and shelling data (unpublished) indicate that shelling action would be more for average grade peanuts (SMK+SS = 73) than for these loads (10 of these 14 loads had SMK+SS <72). Thus the $20.67 per ton higher market value for the peanuts sampled by the ASpS may be a low estimate for average grade peanuts. This higher economic value could be a significant incentive to the farmer for supporting a new marketing strategy that uses an in-line sampler such as the ASpS provided legislation did not require adjustment for differences in the two samplers. Otherwise, adjustments by ASCS would have to be made when using the ASpS. The ASpS would fit more easily than the PS in marketing strategies such as screening prior to marketing since the peanuts must be unloaded and handled in marketing process. Information presented here will be useful in implementing such strategies. This information will also be useful in relating grades to plant outturns. Such information is needed in guiding research to develop shelling models as well as research to determine shrinkage during marketing and storage. Fortunately, the differences in plant outturn and those estimated by the grade were less for the primary factor (SMK+SS) that determines market value than for secondary factors (FM, LSK, TK, OK, DK). The differences for the secondary factors may be related to light foreign material, light pods (pops), small kernels, skins and small meat fragments being removed with the hulls when the peanuts were shelled in the pilot plant. Additional research is needed to develop more accurate equations to predict plant outturns from grade estimates and to provide explanations for the differences.

Table 5. Regression and correlation coefficients for regression of grade estimates (Y) on plant outturns (X).

Grade Factors	PS Slope	Intercept	r	ASpS Slope	Intercept	r
FM	0.93	1.03	0.74	0.78	0.95	0.71
LSK	0.94	1.94	0.54	0.55	1.25	0.46
Seg. III	0.73[1]	12.8[1]	0.76[1]	0.64[1]	10.72[1]	0.77[1]
SMK	0.88	11.19	0.91	0.88	11.86	0.91
SS	0.70	-1.43	0.85	0.59	-0.75	0.83
SMK+SS	0.98	1.97	0.92	0.98	2.35	0.94
OK	1.24	0.37	0.97	1.20	0.32	0.98
DK	2.18	-0.19	0.84	1.39	0.15	0.74
TK	0.64	29.66	0.88	0.63	29.99	0.88

[1]Values were obtained by regressing percent of Segregation III samples on the mean aflatoxin (ppb) contamination of the edible peanuts.

The correlation coefficients were all significant at the 5% level or better, except for LSK from ASpS which was significant at the 10% level.

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