Accuracy and variability in sampling and grading Florunner farmers stock peanuts (1)

Y. J. TSAI[2], F. E. DOWELL[3], J. I. DAVIDSON, Jr.[3], and R. J. COLE[3]

Abstract.— Sampling, grading, and pilot plant shelling studies were conducted on 14 loads of Florunner (*Arachis hypogaea* L.) farmers stock peanuts to determine the variability of grade factors and to provide data for improving the current farmers stock grading system. For all grade factors except total sound mature kernels (TSMK), differences between grade estimates and actual outturns were significant at the above 95% confidence level. Also, there was a general trend of over-estimation for all grade factors, except sound splits (SS). Loose shelled kernel (LSK) estimates were about two times higher than the actual outturns. Regression equations were developed to provide estimates of the milling quality from the sample grades. Variability of the grade within each load was estimated when using the current grade sample size. It appeared that the pneumatic sampling patterns in use for obtaining grade samples did not affect grade estimates. The potential for improving the grading of farmers stock peanuts is discussed.

Key words. — Peanuts, aflatoxin, grading, sampling, *A. flavus*.

INTRODUCTION

The current farmers stock grading system [2] requires each trailer load of peanuts (*Arachis hypogaea* L.) be sampled to determine various grade factors. The percentages of foreign materials (FM) and loose shelled kernels (LSK) are determined by examining an 1800 gram composite subsample taken with a pneumatic probe. The percentages of sound mature kernels (SMK), sound splits (SS), other kernels (OK), total damaged kernels (TDK), hulls (H) and moisture content (MC) of kernels are determined by shelling a 500 g of peanuts removed from the 1800 g subsample. All kernels are examined for *Aspergillus flavus* to determine the potential for aflatoxin contamination. Several prescribed probe patterns are approved for taking this official grade sample [6]. Based on the grade determination from the official grade sample, farmers are paid for the whole trailer load of peanuts. Research [1,7,8] and experience indicate that variability of grade determinations is large, incentives are not readily apparent to farmers willing to make extra efforts for producing good quality peanuts, and grade data does not adequately predict milling quality. In addition, quality problems, such as aflatoxin, foreign material, and off-flavor, threaten the growth of the industry.

In response to these problems, research studies were initiated to evaluate the performance of the current grading system and correlate grades to milling quality. This paper reports the performance of the current system; regression equations to estimate milling quality; and sampling, subsampling and grading variabilities.

(1) Contribution from University of Georgia, Agricultural Engineering Department, Coastal Plain Experiment station, Tifton, GA and USDA, ARS, National peanut research laboratory, Dawson, GA.

(2) Senior data analyst, Southwest Florida water management, 2759, Broad Street, Brooksville, FL 34609-6899.

(3) Agricultural engineer, mechanical engineer and research microbiologist, USDA, ARS, National peanut research laboratory, Dawson, GA.

MATERIALS AND METHODS

During the 1986 harvest season, one trailer load of Florunner farmers stock peanuts was selected from each of 14 commercial fields in Georgia. After marketing, three official probe patterns, Nos. 3, 5, and 10, [6] were used to obtain 20 kg samples from each trailer. After sampling, the peanuts in each trailer were weighed and transported to the USDA, National Peanut Research Laboratory (NPRL) pilot shelling plant to determine shelling outturns and grade factors.

Using FSIS farmers stock peanut dividers, each 20 kg sample was subdivided further to provide 10 subsamples for official grading. Thus, a total number of 420 subsamples were taken for official grade determinations (14 trailers × 3 samples × 10 subsamples = 420). Subsamples were then coded and taken to FSIS for grade analyses.

The standard official grade analyses [6] included using the 1800 gram and 500 gram subsamples. Since MC of subsamples were not measured immediately after grading and subsamples were not graded at the same time, variations of moisture measurement were not investigated in this study. Since hulls are not used in calculating market value, hulls were also deleted from the analyses.

Actual outturns of each trailer load were determined from the output of the NPRL pilot shelling plant. For pilot plant outturns of Florunner peanuts, SMK were the sum of large (jumbos), medium (mediums) and small (No. 1's) whole kernels. SS was the shelled grade of split kernels. OK consisted of small whole kernels and small pieces of broken kernels.

The sampling procedure for aflatoxin of shelled stock peanuts was detailed in another study [5]. F&V Process Product Division, USDA, AMS, Albany, Georgia measured shelled stock aflatoxin levels using thin-layer chromatography (TLC). The total aflatoxin of each load was the weighted mean of the edible and oil stock grades. The edible grade consisted of SMK and SS, while OK and LSK were grouped into the oil stock grade.

The data was analyzed by the SAS [3] standard statistical procedures and as described by Snedecor and Cochran [4].

TABLE I. — Grade estimates and actual outturns of 14 loads of farmers stock peanuts

Load	Number of subsamples (1)	Foreign material		Loose shelled kernels		Mean of *A. flavus* kernels	Aflatoxin conc. in outturn		% samples with *A. flavus* kernels
		Grade	Outturn	Grade	Outturn		Edible	Total	
		%		%			ppb		
1	24	3.94	2.57	2.77	0.91	0	0	0.09	0
2	30	2.03	1.74	2.47	1.47	0	0	0.87	0
3	30	3.25	2.89	4.51	2.54	0	0	0.64	0
4	30	3.12	2.88	4.35	1.71	0.03	1.30	1.26	3.3
5	30	2.03	2.54	2.46	1.94	0	0.23	2.03	0
6	27	3.79	2.89	2.54	3.13	0	0	2.56	0
7	30	4.84	4.28	7.00	2.87	0.03	0.28	3.09	3.3
8	30	2.67	2.52	3.12	2.05	0	0	4.13	0
9	21	3.94	2.42	4.57	2.01	1.00	21.85	20.63	61.9
10	23	3.59	2.33	4.33	1.76	2.48	18.54	52.22	100
11	30	4.73	5.05	4.95	3.10	0	0.27	49.27	0
12	28	4.92	4.81	5.90	3.59	1.46	86.80	106.84	71.4
13	30	2.52	1.69	3.88	2.80	4.27	121.48	179.18	100
14	30	7.40	4.12	3.34	2.06	0.70	(2)	(2)	33.3
Mean		3.86	3.05	4.09	2.28	0.71	19.29	32.52	26.9

Load	Number of subsamples (1)	Sound mature kernels		Sound splits		Total sound mature kernels		Other kernels		Total damaged kernels		Total kernels	
		Grade	Outturn	Grade	Outturn	Grade	Outturn	Grade	Outturn	Grade	Outturn	Grade	Outturn
		%		%		%		%		%		%	
1	24	58.4	56.6	1.3	5.1	59.7	61.7	12.3	8.5	1.1	0.7	73.2	70.2
2	30	67.0	62.9	3.3	6.1	70.3	69.0	7.6	5.3	0.5	0.3	78.4	74.3
3	30	64.6	59.6	4.6	9.6	69.2	69.2	7.9	6.0	1.3	0.6	78.3	75.2
4	30	66.4	63.1	5.7	9.5	72.1	72.6	5.6	3.7	0.7	0.4	78.4	76.3
5	30	67.0	66.0	3.3	4.5	70.3	70.5	7.6	2.9	0.4	0.3	78.4	73.4
6	27	60.1	56.3	1.8	5.3	61.9	61.6	12.1	7.6	0.4	0.2	74.4	69.2
7	30	63.8	57.3	5.8	9.8	69.6	67.1	7.0	6.6	0.8	0.5	77.5	73.7
8	30	66.6	65.9	6.1	7.6	72.7	73.5	4.9	3.6	0.3	0.3	77.9	77.1
9	21	62.6	53.2	4.8	9.2	67.4	72.4	7.0	5.9	0.8	0.6	75.2	68.3
10	23	64.8	57.6	3.6	8.0	68.4	65.6	6.1	5.4	0.7	0.5	75.2	71.0
11	30	63.5	57.0	9.3	14.5	72.8	71.5	4.4	3.6	0.9	0.7	78.1	75.1
12	28	58.1	57.9	1.7	7.6	59.8	65.5	15.9	12.2	1.2	0.8	76.9	77.7
13	30	69.9	67.0	2.6	6.8	72.5	73.8	3.5	2.8	0.7	0.4	76.8	76.6
14	30	47.4	44.0	2.5	5.3	49.9	49.3	16.5	14.1	1.3	0.6	67.8	63.4
Mean		63.2	58.9	4.1	7.8	67.3	66.7	8.1	6.3	0.8	0.5	76.2	73.0

(1) After sampling and subsampling, some of the 30 samples were infested by rodents. These subsamples were deleted from the study.
(2) After sampling, aflatoxin for load 14 was confounded by humid environment produced during fumigation.

TABLE II. — Linear regression coefficients of grades predicted by shelling outturns

Grade Factor	Linear regression		
	Intercept	Slope	
	a	b	r^2
FM	1.031	0.930	0.56
LSK	1.937	0.942	0.30
SMK	11.191	0.882	0.83
SS	-1.398	0.701**	0.73
TSMK	1.970	0.978	0.86
TDK	0.186	0.355	0.30
OK	0.368	1.240**	0.94
TK	29.655*	0.637**	0.77

*a is significantly different from zero (P = 0.05)
**b is significantly different from one (P = 0.05)

TABLE III. — Analysis of variance (ANOVA) when using a pneumatic probe with 3 sampling patterns and 10 subsamples per pattern to estimate grade factors of 14 loads of farmers stock peanuts

	Mean of sum of square			Variance	
Grade factor	Load(13)[1]	Sample (28)	Subsample (351)	Sampling	Subsampling
---1800 gm---					
FM	53.169	1.035	0.942	0.009	0.942
LSK	47.857	1.525	1.396	0.013	1.396
AF Kernels	45.977	0.777	0.858	–	0.858
---500 gm---					
SMK	1012.418	3.708	1.872	0.184	1.872
SS	134.367	2.108	0.838	0.127	0.838
TSMK	1385.160	1.772	1.388	0.038	1.388
OK	536.177	0.843	0.771	0.007	0.771
TDK	3.302	0.121	0.132	–	0.132
TK	251.992	0.268	0.247	0.002	0.247

(1) Degree of freedom

RESULTS

Table I shows mean grade estimates and actual pilot plant outturns. In most cases, sample grades overestimated shelling outturns, except for SS. The presence of one or more *A. flavus* kernel requires that the peanuts be segregated (Seg. 3) and used for non-edible purposes. *A. flavus* kernels were found in 3% of the grade samples from 2 loads of peanuts with less than 2 ppb aflatoxin in the edible shelled peanuts. *A. flavus* kernels were found in 62-100% of the grade samples taken from 4 loads of peanuts having an estimated 19-121 ppb in the edible shelled peanuts.

A significance test (paired t-test) of difference between actual plant outturn and mean grade estimate was performed. Except for TSMK, the sample estimates were significantly different from actual outturns at the 95% confidence level. The average for SS was underestimated primarily because the official grade sheller had a more gentle shelling action and produced lower split outturns than obtained with the commercial type sheller. The overestimate of LSK probably resulted form the pneumatic sampler producing more LSK by actions of the sampling probe and the air transport of peanuts to the sample divider. The tendency of overestimation or underestimation of grade factors suggested that regression equations could relate the grade estimates to the outturns.

Since the plant outturn error is smaller than the grade error, slopes and intercepts were determined by relating grade estimates (Y) to outturns (X) by the linear regression.

$$Y = a + b X$$

where a and b are intercept and slope of the regression line, respectively. In the future, given a new trailer load of FS peanuts, x is predicted by measuring Y. For every grade factor, the linear regression of the actual outturn from grade estimate is presented in table II. Most intercepts were not significantly different from zero and the slope for FM, LSK, SMK and TSMK were not significantly different from one.

The analysis of variance of grade factors when sampling and subsampling the 14 loads of Florunner peanuts are presented in table III. It was not surprising that the mean of sum of squares attributed to trailer loads was very large, because trailers were selected from different fields. Assuming the variation among the 3 samples from the 3 probes was due to sampling (ignoring the probe-to-probe variation), variances of sampling and subsampling were calculated and tabulated in table III. Variances of sampling grade factors were relatively small and the probe variance was also small. Thus, ignoring the probe-to-probe variation appeared reasonable. As calculated, sampling variances of TDK and *A. flavus* kernels were negative. Subsampling variances of sampled grade factors in the order from the highest to the lowest were SMK, LSK, TSMK, FM, SS, OK, TK and TDK. The variance of *A. flavus* kernels in subsamples was 0.858.

DISCUSSION

Over-estimation of grade factors other than SS does not present an immediate problem to the seller because the market price structure has evolved over a period of years to account for these previous unknown differences but gives the buyer inaccurate information about lot quality. However, if the peanut program or marketing procedures are changed, these and other data should be considered on making such changes. Fortunately, the smallest difference is between TSMK and the pilot plant outturn. This grade is the primary factor used in setting the price of edible grade farmers stock peanuts. Careful use of the regression equations should be beneficial in providing estimates of the actual plant outturns and developing additional incentives for reducing problems with aflatoxin, foreign material, immaturity (indicated by OK), and off-flavor (indicated by SS).

Of primary concern is the variability associated with the grade factors, especially those related to major industry problems such as aflatoxin (*A. flavus* kernels), foreign material, immaturity, and off-flavor. The need for better sampling and grading methods to reduce this variability is very evident. Using more or larger samples will reduce the variability, but practical economic limitations, such as equipment size and cost as well as loss of good peanut materials, must be considered in determining a feasible size and number of subsamples. A practical solution will probably involve larger subsamples as well as better sampling and grading methods.

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RESUME

La précision et la variabilité de l'échantillonnage et du classement des archides Florunner dans les stocks des agriculteurs

Y.J. TSAI, F.E. DOWELL, J.I DAVIDSON Jr. et R.J. COLE, *Oléagineux*, 1993, 48, N°12, p. 511-514

Des études d'échantillonnage, de classement et de décorticage en unité pilote ont été réalisées sur 14 lots d'arachide Florunner (*Arachis hypogaea* L.) provenant de stocks chez les agriculteurs afin de déterminer la variabilité des facteurs de classement, et de fournir des informations permettant d'améliorer le système actuel de classement des stocks chez les agriculteurs. Pour tous les facteurs de classement à l'exception des amandes mûres et saines totales (AMST), les écarts entre les classements estimés et les classements réels sont significatifs pour un seuil de confiance supérieur à 95%. Par ailleurs, il existe une tendance générale à la surestimation pour toutes les catégories à l'exception des brisures saines (BS). Les estimations relatives aux amandes décortiquées en vrac (ADV) sont environ deux fois plus élevées que les valeurs réelles. Des équations de régression ont été établies afin d'estimer la qualité en huilerie à partir des catégories d'échantillons. La variabilité du classement au sein de chaque lot a été estimée lors de l'utilisation d'échantillons de taille courante. Il paraît que les dispositifs d'échantillonnage pneumatiques utilisés pour obtenir des échantillons de catégories n'influencent pas les estimations de catégories. Les possibilités d'amélioration du classement des stocks d'arachide chez les agriculteurs sont discutées.

Mots clés. — Arachide, aflatoxine, classement, échantillonnage, *A. flavus*

RESUMEN

Precisión y variabilidad del muestreo y de la clasificación de los manís Florunner en las existencias de agricultores

Y.J. TSAI, F.E. DOWELL, J.I. DAVIDSON Jr y R.J. COLE, *Oléagineux*, 1993, 48, N°12, p. 511-514

Se han realizado estudios de muestreo, de clasificación y de descascarillado en unidad piloto en 14 lotes de maní Florunner (*Arachis hypogaea L.*) que oriundan de existencias de agricultores a fin de determinar la variabilidad de los factores de clasificación, y de proporcionar informaciones que permitan mejorar el sistema actual de clasificación de las existencias de agricultores. Para todos los factores de clasificación con excepción de las almendras maduras y sanas totales (AMST), las desviaciones entre las clasificaciones estimadas y las clasificaciones reales son significativas para un umbral de confianza superior al 95%. Por otro lado, existe una tendencia general a sobrevalorar todas las categorías con exepción de las roturas sanas (BS). Las estimaciones relativas a las almendras descascarilladas a granel (ADV) son quasi dos veces más altas que los valores reales. Se establecieron ecuaciones de regresión para estimar la calidad en fábrica de aceite a partir de categorías de muestras. Se estimó la variabilidad de la clasificación dentro de cada lote al emplear muestras de tamaño corriente. Parece ser que los dispositivos de muestreo neumático utilizados para lograr muestras de categorías no influencian las estimaciones de categorías. Se discute sobre las posibilidades de mejoramiento de la clasificación de las existencias de manís de agricultores.

Palabras claves. — Maní, aflatoxina, clasificación, muestreo, *A. flavus*