Effects of Overweight Samples and Rounding of Grade Percentages on Peanut Grades and Prices

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ABSTRACT

Two possible sources of error in measuring grade factors and prices with the current peanut (*Arachis hypogaea* L.) grading procedure are rounding of grade factors and taking overweight samples. Rounding did not affect average grade factors or prices. Instead, rounding introduced noise, increased the probability of regrading, and provided an incentive for taking overweight samples. Taking overweight samples resulted in higher producer prices. A 1% increase in the sample weight resulted in a 1% increase in the producer price. A policy implication is that USDA should round to tenths rather than whole percentages.

Key Words: *Arachis hypogaea* L., grade factors, producer prices.

There is a potential to increase the accuracy of the current U.S. peanut (*Arachis hypogaea* L.) grading system by reducing rounding and removing the incentives to take overweight samples. With the current grading procedure, the measurement of grade factors begins with a cleaned sample weight of 500 g for truckloads of 10 t or less. [Note that foreign matter (FM) and loose shelled kernels (LSK) are removed and measured during cleaning. Percentages of these factors are measured using actual beginning weight and with little rounding. Errors in measuring FM and LSK do not occur due to rounding or overweight samples. Such errors may be a bigger problem, but they are not due to a poorly designed grading system.] For single loads of over 10 t, a 1000-g sample is used (USDA, 1996). The set of grade factors measured are the percentages of sound mature kernels (SMK), sound splits (SS), other kernels (OK), total damage (TD), and hulls. To check the accuracy of the grade factors measured, graders add up the percentages of total kernels and hulls. The grading system stipulates that peanuts must be regraded if the final sum of total kernels and hulls is less than 99% or greater than 101%.

Assuming a cleaned sample in the range of 500 to 505-g and no weight loss in the process, grading without rounding (but dividing by 500 g regardless of the initial sample weight), leads to a final percentage sum in the range of 100 (500/500) to 101 (505/500). This range is still acceptable and regrading would not be necessary. However, rounding introduces errors in the range of 2% leading to a final percentage sum between 98 and 103%, even with no weight loss.

Regardless of the grader's ability, some weight is lost during the grade analysis, and there is usually a discrepancy between the weight before and after grading. The weight discrepancy found after grading comes from the sample weight lost as dust and kernels during the analysis, and infrequent human errors. The weight lost is mostly dust or dirt created when the sample is shelled. Also, small pods or kernels can fall through the sheller grate or get stuck in the grading screen. Under time pressure, graders may forget to clean the pan containing kernels from a previous analysis or might accidentally drop some kernels when grading. These kernels may show up in the next sample graded. Hence, graders sometimes have total kernels and hulls greater than the initial sample weight. Human or mental errors include errors in recording weights, calculating the percentages, and transcribing the results (Powell *et al.*, 1994). Usually graders do not lose pods and kernels or make errors but, when they do, the errors may be large.

Accurate pricing of peanuts depends on accurate grading. We have observed some graders taking samples slightly greater than the prescribed 500-g to 500.5-g range, presumably to reduce chances of regrading. This is a possible source of error in peanut grading. Due to time constraints and pressure during peak hours of the grading season, graders may use an overweight sample to ensure the allowable tolerance is met if some of the sample is lost during grading. For example, if a 500-g sample is required, graders are allowed to use a sample weight between 500.0 and 500.5 g, but they may begin with a 501-g sample. Sample weights greater than 500 g result in more peanuts in the sample. Previous research consistently shows that increasing sample sizes is one component of total measurement error that can affect grade factors (Dowell, 1992). Using initial samples in excess of 500 g while still dividing by 500 g results in overestimated grade factors and subsequent excessive peanut price. There is a need to document the effects of the problem of overweight samples so that, for example, formal training programs for peanut graders can show the need for starting with a sample size as close to 500 g as possible. The problems of rounding and overweight samples are worthy of study because policies to alleviate them may be adopted at a low cost.

The purpose of this study was to estimate (a) the variability of producer prices introduced by rounding of grade percentages to the nearest whole number, (b) the effects of overweight samples and weight discrepancy on grade factors measured, (c) the effect of overweight samples on the producer price, and (d) the probability of regrading as a function of the initial sample weight.

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Materials and Methods

An experiment was carried out at the buying point of Colvin, OK from 21 Jan. to 24 Jan. 1997. The experiment used eighty-three 2100-g cleaned samples of runner and spanish peanuts collected from grading stations across the state of Oklahoma during the 1996 harvest season. The samples were taken from dryer wagons containing about 4 t (8000 lb) of peanuts with a pneumatic probe. Foreign matter and loose shelled kernels were removed. Twenty-five samples were runner-type peanuts and 58 samples were spanish-type peanuts. The samples included a range of quality and cleanliness characteristics. Each sample was then divided into four subsamples of approximately 500.0, 501.4, 503.7, and 505.0 g in order to have four different sizes from the same sample. Grade factors were measured by three professional graders and two aides. They were asked to complete the measurements quickly to simulate conditions during the peak of the grading season. The experiment generated data on the initial sample weights in grams, grade factors measured in grams and percentages, weight discrepancy in grams (this is the difference in sample weight before grading and total sample weight after grading), and associated producer prices in dollars.

To test the hypothesis that rounding had no effect on producer prices, a paired-differences test was used. Five pairs of pricing methods were compared to estimate the variability of producer prices introduced by rounding of grade factors. The first pricing method was the current U.S. peanut pricing method; that is, the producer price came from grade percentages calculated with rounding and assuming a 500-g sample regardless of actual initial sample weight (rounding/500-g sample). The second method determined producer price using unrounded grade percentages and assuming a 500-g sample weight (no rounding/500-g sample). The next two pricing methods were with and without rounding, but producer prices were calculated using percentages determined using actual sample weight. Finally, to compare the actual method to the ideal method, the 'Rounding/500-g sample' vs. the 'No rounding/actual sample' methods were compared. The variability of producer prices was given by the standard deviation of the paired differences.

To determine the effects of overweight samples and weight discrepancy on grade factors measured, random effects models were used (fixed effects models yield very similar answers). Linear equations were estimated by regressing grade factor against sample weight and weight discrepancy. For example, the equation for SMK in grams with random effects models was:

$$SMK_{ij} = \beta_0 + \beta_1 SAMPLE_{ij} + \beta_2 DISCREPANCY_{ij} + \upsilon_i + \nu_{ij} \quad \text{[Eq. 1]}$$

where SMK_{ij} is the weight of sound mature kernels in grams measured from the i^{th} truckload and j^{th} subsample size, $SAMPLE_{ij}$ is the initial sample weight in grams, $DISCREPANCY_{ij}$ is the weight discrepancy in grams, and $\upsilon_i + \nu_{ij}$ is the error term of the random effects model.

Similarly, to test the effect of overweight samples on the producer price, random effects models were also used. Logarithmic price equations were calculated by regressing the logarithm of the producer price in dollars (*LOGPRICE*) against the logarithm of the initial sample weight in grams (*LOGSAMPLE*). The model in Eq. 1 can be reformulated as:

$$LOGPRICE_{ij} = \alpha_0 + \alpha_1 LOGSAMPLE_{ij} + \tau_i + \varepsilon_{ij} \quad \text{[Eq. 2]}$$

where τ_i is the random effect corresponding to the i^{th} truckload, and ε_{ij} is the error term. Parameters in Eqs. 1 and 2 were estimated with PROC MIXED in SAS.

The probability of regrading is the probability of having total kernels and hulls outside the 99-101% interval. The probability distribution of weight discrepancy was modeled using a normal-jump distribution. The normal-jump distribution combines a normally distributed error, that is always present, with another normally distributed error, whose probability of occurrence also depends on Poisson probabilities (Pebe Diaz, 1999). Weight discrepancy occurs due to weight lost as dust and infrequent human errors. We could assume normality for the weight discrepancy due to dust and for weight lost due to infrequent human errors. Thus, the normal distribution that is always present represents weight lost as dust, and the human error occurrences follow Poisson probabilities. The distribution of weight discrepancy and the equations defined in equation 1 were used to set up the integrals to calculate the probability of being outside the 99-101% interval. The integrals were solved with Monte Carlo methods.

Results

In general, rounding introduced noise into the measurement of producer prices (Table 1). The standard deviation of the difference in producer prices with and without rounding was \$3.30/t when dividing by 500 g and, when dividing by the actual sample weight, was \$3.35/t. The overweight samples in this experiment introduced a standard deviation of \$4.28/t when rounding was used and \$2.30/t with no rounding. Thus, graders using various sample weights also introduce noise into the measurement of producer prices.

The hypothesis that average producer prices were the same under two different pricing methods was rejected for the 'Rounding/500-g' method vs. the 'No Rounding/Actual Sample' method. This hypothesis also was rejected for the 'Rounding/500-g' vs. 'Rounding/Actual Sample', and the 'No Rounding/500-g' vs. 'No Rounding/Actual Sample' pricing methods. However we failed to reject that average producer prices were the same under the 'Rounding/500-g' vs. 'No Rounding/500-g' and the 'Rounding/Actual Sample' vs. 'No Rounding/Actual Sample' methods at a 5% significance level. Thus, rounding did not significantly affect mean prices. Dividing by 500 g rather than actual sample weight did result in significantly higher prices.

The effect of overweight samples on grade factors was only significant for sound mature kernels (SMK) and hulls (Table 2). The other categories made up a small part of total weight and so their equations were estimated less accurately. Hence, taking overweight samples will result in increased SMK, and thus in higher prices, and hulls. This is because the peanut pricing system is a component pricing system with SMK being the primary factor determining peanut prices. The effect of the weight discrepancy on grade factors was found to negatively influence SMK. This

Table 1. Descriptive statistics of four pricing methods using paired differences on peanut producer prices.[a]

Description	Mean	Standard dev.	Min.	Max.
	--------------- $/100 kg ---------------			
Prices with rounding/500-g sample	662.96	22.96	603.43	739.78
Prices with no rounding/500-g sample	662.68	22.37	606.35	733.43
Paired differences[b]	0.28	3.64	-7.10	8.80
Mean square error	12.06	14.33	0.00	70.22
Number of observations	314			
Prices with rounding/actual sample	660.07	22.86	603.43	731.21
Prices with no rounding/actual sample	659.69	22.31	602.49	728.12
Paired differences[c]	0.40*	3.69	-7.75	9.16
Mean square error	12.50	14.53	0.00	76.10
Number of observations	296			
Prices with rounding/actual sample	662.65	22.83	603.43	739.78
Prices with no rounding/actual sample	659.45	22.39	603.43	730.33
Paired differences[d]	3.20**	4.72	-9.46	18.03
Mean square error	29.40	46.61	0.00	295.11
Number of observations	298			
Prices with rounding/actual sample	663.28	22.52	606.35	733.43
Prices with no rounding/actual sample	659.90	22.24	602.49	728.08
Paired differences[e]	3.38**	2.54	-0.84	8.28
Mean square error	16.19	16.40	0.00	62.13
Number of observations	313			
Prices with rounding/actual sample	663.00	22.89	603.43	739.78
Prices with no rounding/actual sample	659.37	21.93	602.49	728.08
Paired differences[f]	3.65**	4.35	-7.17	14.67
Mean square error	29.15	36.77	0.00	194.94
Number of observations	292			

[a]All prices related to observations requiring regrading have been excluded. Variability of prices is defined as the standard deviation of the paired differences. Total number of observations is 332.

[b]The observed value of the t-statistic is 1.34.

[c] The observed value of the t-statistic is 1.85.

[d]The observed value of the t-statistic is 11.70.

[e]The observed value of the t-statistic is 23.61.

[f]The observed value of the t-statistic is 14.32.

*,**Prices are significantly different at the 90 and 95% level of confidence, respectively.

implies that most of the large errors are in measuring SMK. Formal training programs for peanut graders should then focus on how to carefully measure SMK.

The use of overweight samples had a significantly positive relationship with the producer price (Table 3). The null hypothesis that the percentage change in price with a 1% change in sample weight (i.e., elasticity) was one (H^0: $\alpha 1$ = 1 in Eq. 2) was not rejected. Therefore, a 1% increase in the sample weight results in a 1% increase in the producer price.

Table 2. Parameter estimates of the grade factor linear equations with random effects models.[a]

Parameter	Estimate	Standard error	P-value
Sound mature kernels (SMK)			
Intercept	-119.4897	76.77	0.124
Sample weight	0.8751*	0.15	< 0.0001
Weight discrepancy	-0.7296*	0.33	0.028
Between-groups variance	286.3887		
Within-groups variance	26.0712		
Sound splits (SS)			
Intercept	90.5113	57.73	0.121
Sample weight	-0.1222	0.12	0.290
Weight discrepancy	-0.0961	0.25	0.700
Between-groups variance	272.7718		
Within-groups variance	14.7302		
Other kernels (OK)			
Intercept	25.7835	42.97	0.550
Sample weight	-0.0035	0.09	0.968
Weight discrepancy	-0.0670	0.18	0.715
Between-groups variance	54.8105		
Within-groups variance	8.1760		
Total damage (TD)			
Intercept	17.5863	14.68	0.235
Sample weight	-0.0308	0.03	0.294
Weight discrepancy	-0.0464	0.06	0.439
Between-groups variance	1.3978		
Within-groups variance	0.9597		
Hulls			
Intercept	-14.0701	26.74	0.600
Sample weight	0.2807*	0.05	< 0.0001
Weight discrepancy	-0.0580	0.12	0.616
Between-groups variance	94.5386		
Within-groups variance	3.1567		

[a]Grade factors in grams have been calculated with no rounding since weight discrepancy is a continuous variable.

*Statistically significant at the 95% confidence level.

Table 3. Parameter estimates of the price logarithmic equations with random effects models.[a]

Parameter	Estimate	Standard error	P-value
Prices with rounding			
Intercept	0.8111	1.03	0.4310
Sample weight	0.8983**	0.16	< 0.0001
Between-groups variance	0.0011		
Within-groups variance	0.0001		
Prices with no rounding			
Intercept	0.2530	0.85	0.7656
Sample weight	0.9881**	0.14	< 0.0001
Between-groups variance	0.0010		
Within-groups variance	0.0001		

[a]Producer prices are calculated based on grade percentages with rounding/500-g sample and with no rounding/500-g sample.

**Statistically significant at the 95% confidence level.

Values of the weight discrepancy have ranged from −24.20 to 47.70, with the mean and the variance being 2.77 and 4.44, respectively. The normal-jump distribution of the weight discrepancy in grams was estimated to calculate the probability of regrading without rounding. The normal-jump distribution separates the weight loss into two components. One is normally distributed and represents sample weight lost as dust while the other component occurs with a certain probability and represents infrequent human errors (for a complete explanation of the procedure, see Pebe Diaz, 1999). The normal process associated with the sample weight lost as dust suggested that graders making no errors averaged losing 2.26 g of the sample. The 95% confidence interval around this estimate, 0.32-4.20 g, falls within the allowable tolerance (5 g or 1% of the sample weight). The probability of losing 5 g when no large error is made was only 0.0023. This result suggests that the range of the allowable tolerance is reasonable. The jump process was assumed to be associated with infrequent human errors. The probability of occurrence of a large human error was 7.05%, with the size of this error being 5.90 ± 12.05 g. The probability of regrading calculated using the estimated jump-diffusion model is plotted in Fig. 1 as a function of the initial cleaned sample weight. When rounding was not used, the sample weight had little effect on the probability of regrading. With rounding, the probability of regrading decreased from approximately 0.08 for a 500-g sample to approximately 0.05 for a 503-g sample. The probability of regrading then increased as initial sample weight increased. Thus, rounding does provide a strong incentive to use overweight samples.

Discussion

These findings have important implications for changes in policies and regulations aimed at refining the U.S. peanut grading system. The current use of rounding directly introduced noise, increased costs due to more frequent regrading, and provided a major incentive for peanut graders to use overweight samples. A very low cost method to improve the peanut grading system would be to abolish rounding. Peanut graders have told us that they believe taking overweight samples (i.e., greater than 500.5 g) does not matter because of the use of rounding. The results of this study demonstrated that a larger sample weight leads to overestimating the grade percentages such as SMK and thus prices.

Rounding allows graders to do calculations mentally. Now that computers are readily available, the extra computational efforts of measuring grade factors in grams or rounding to tenths rather than whole numbers would be small. If the range of allowable initial weights was widened, there could be some time savings also from reducing the time it takes to get an initial weight inside the allowable range. The time savings from reduced regrading would be substantial.

It might first appear that reducing overweight samples would reduce the payment producers receive. If buyers are competitive, however, the overall price of peanuts would change in response to the change in measurement. Average producer payments might even increase due to greater efficiency and lower risk to buyers. Reducing overweight samples would, however, in effect reduce payments for quota peanuts when prices are at support levels.

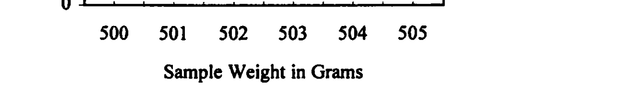

Fig. 1. Probability of regrading in the U.S. peanut industry (Note: The probabilities are calculated using an estimated normal-jump distribution with percentages calculated by dividing by 500 g).

Conclusions

Rounding increased the variability of producer prices. However, rounding did not affect average grade factors or producer prices. Instead, rounding directly introduced noise, increased the probability of regrading, and provided an incentive to take overweight samples. Taking overweight samples did result in higher producer prices. The easiest policy change to implement to correct the problem would be to round percentages to tenths rather than whole numbers. An alternative policy change would be to calculate percentages based on the exact initial cleaned sample weight rather than dividing by 500 g.

Literature Cited

Dowell, F.E. 1992. Sample size effects on measuring grade and dollar value of farmers' stock peanuts. Peanut Sci. 19:121-126.

Pebe Diaz, E.F. 1999. Refining the U.S. peanut grading system. Unpub. PhD Diss. Oklahoma State Univ., Stillwater.

Powell, Jr., J.H., H.T. Sheppard, and F.E. Dowell. 1994. An automated data collection system for use in grading of farmers' stock peanuts. Paper 6501/6523, 1994 Int. Winter Meeting, Amer. Soc. Agric. Eng. (ASAE), Atlanta, GA.

USDA, Agricultural Marketing Service. 1996. Farmers' Stock Peanuts Inspection Instructions Handbook Update 133. U.S. Govt. Print. Ofc., Washington, DC.