Peanut Science (1982) 9, 30-33

Variation in Milling Quality of Peanuts[1]

J. C. Wynne[2]

ABSTRACT

Poor milling quality of peanuts (*Arachis hypogaea* L.) results in a substantial financial loss to the peanut industry. With recent development of a sheller and methodology for the evaluation of milling quality for small samples, it is possible for a peanut breeder to evaluate and select a desired level of milling quality. This study was conducted to determine the variation in milling quality among several large-seeded virginia cultivars and among a group of breeding lines from the cross of the virginia cultivars, NC 5 and Florigiant.

Cultivars were significantly different for milling quality. However, cultivars did not perform consistently over years, locations or harvest dates.

Large differences in milling quality among F_2 families measured in the F_6 generation for the cross of NC 5 and Florigiant were observed. Selection for milling quality among the F_5 lines should be effective; however, selection for milling quality without consideraiton of blanching properties may result in the development of breeding lines unacceptable to end-use product manufacturers.

Key Words: *Arachis hypogaea*, peanut breeding, seed splitting, selection, heritability.

Milling quality, the ability of peanut (*Arachis hypogaea* L.) seeds to resist splitting and skinning by commercial shelling and processing equipment, is important to shellers since it is a major factor in market value. Excessive split seeds result in a substantial financial loss. Woodward (7) found that the testa provides most of the resistance to splitting. Rapid drying weakened the testa and increased split and skinned seeds.

Methods to measure the ability of seeds to resist splitting and skinning using small samples were not available until recently. McIntosh *et al.* (4) developed a one-quarter size commercial sheller for determining milling quality of samples as small as 9 kg. Davidson and McIntosh (2) then developed a sheller that provided an accurate and reliable method for determining milling quality of 2-kg samples of peanuts. The development of this machine makes it possible for peanut breeders to evaluate breeding lines in early generations when only small samples of seed are available.

The milling quality of peanut breeding lines is usually evaluated when the line is being considered for release as a cultivar. At this stage if milling quality is unacceptable, the line must be discarded. For greatest efficiency breeding lines with poor milling quality should be discarded during the initial stages of selection. Little information on milling quality of peanut breeding lines is available.

The objectives of this study were (a) to determine the variation in milling quality of large-seeded virginia (ssp. *hypogaea* var. *hypogaea*) peanut cultivars and breeding lines grown over years and locations and (b) to estimate the variability in milling quality among segregates of a cross between two virginia cultivars.

Materials and Methods

Milling quality was determined using a Model 3 peanut sheller and methods developed by Davidson and McIntosh (2). A 908-g sample of fruit from each field plot was shelled using the mechanical sheller. The material passing through the sheller was screened and separated into unshelled fruit (W_u), bald seeds [at least 50% of testa removed (W_b)], split seeds (W_{sp}) and whole seeds. All were weighed in grams. Peanuts remaining in the sheller were removed and weighed (W_c). Milling quality (M) was computed by the following formula:

$$M = (W_b + W_{sp}/W_s) \times 100$$

where $W_s = 908 - W_u - W_c$.

Computed in this manner, lower values indicate superior milling quality.

Variation Among Cultivars

Eleven large-seeded virginia cultivars and five breeding lines were grown at the Upper Coastal Plain Research Station, Rocky Mount, NC and the Peanut Belt Research Station, Lewiston, NC during 1975 and 1976. Each test was harvested at two dates except for the test at Rocky Mount during 1975 which was harvested once. All tests were replicated twice except the 1975 test at Lewiston which was replicated four times. The 1975 tests were planted on 5 and 8 May for Lewiston and Rocky Mount, respectively. The Rocky Mount test was harvested on 30 September while the Lewiston tests were harvested on 29 September and 13 October. The 1976 tests were planted at Lewiston and Rocky Mount on 4 and 12 May, respectively. The tests were harvested on 28 September and 11 October at Lewiston and 5 and 14 October at Rocky Mount.

Plots were dug, combined, and dried using conventional peanut harvesting and drying equipment. The data were analyzed using the general linear model procedure of SAS since the analysis of variance was unbalanced due to the different number of harvest dates and replications at each location (1).

Variation for Cross Segregates

Milling quality was determined for peanuts from near-homozygous lines generated from the cross of two virginia cultivars grown in a single environment. Individual plants from NC 5 and Florigiant were crossed in reciprocal. Twenty F_2 progeny were chosen at random from an F_1 plant of each cross. Two random F_3 plants were chosen from each F_2 plant and two random F_4 plants from each F_3 plant producing a hierarchial structure which allowed genetic variance components to be estimated for F_6 generation lines using the methods of Hanson and Weber (3). The genetic variability of the F_6 generation lines generated from this hierarchial structure was partitioned into additive and additive x addi-

[1]Paper no. 8066 of the North Carolina Agricultural Research Service, Raleigh, NC 27650.

[2]Associate Professor of Crop Science, North Carolina State University, Raleigh, NC 27650.

tive genetic variances.

The 160 F_6 generation lines and the two parents were grown at the Peanut Belt Research Station during 1976. Reciprocal crosses were tested separately but in adjacent blocks. Each entry was replicated three times. Distance between plants was 25.4 cm within rows and 91 cm between rows. Each plot consisted of two rows of 35 plants each. The test was planted 6 May and harvested 6 October. The fruit was harvested and dried using conventional peanut equipment.

Genetic variances were estimated by the method of maximum likelihood assuming the relevant mean squares were distributed as multiples of independent chi-square random variables (5). The data were analyzed for each reciprocal cross separately. Narrow-sense heritability was estimated using the following formula:

$$h^2 = \frac{\sigma^2_A + \sigma^2_{AA}}{\sigma^2_{E/r} + \sigma^2_A + \sigma^2_{AA}}$$

where σ^2_A = estimate of additive genetic variance,
σ^2_{AA} = estimate of additive x additive genetic variance,
σ^2_E = estimate of error, and
r = number of replications.

This heritability estimate applies to selection of a line in the F_6 generation based on its mean over replications in a single environment.

Results and Discussion

All environmental factors (*i.e.*, locations, years, and digging dates) influenced the milling quality of the virginia peanuts (Table 1). Not only was variation due to years, locations, and digging dates significant but all of the interactions involving these sources of variation had a significant effect on milling quality. The mean over both years for the milling quality of peanuts grown at Lewiston was superior (*i.e.*, lowest mean) to the mean obtained for Rocky Mount-grown peanuts; however, the average milling quality was only superior at Lewiston during 1975 (Table 2). The significant effect of years can also be attributed to the low mean for milling quality at Lewiston during 1975. The differential response for the two years for the Lewiston location resulted in a significant year x location interaciton.

Table 1. Mean squares from analysis of variance combined over years and locations for milling quality.

Source	df	Mean squares
Year	1	2261.8656**
Location	1	779.4977**
Year x location	1	2060.5525**
Harvest date (year x location)	3	5844.3782**
Error a	11	4.5479
Cultivars	15	107.6206**
Year x cultivar	15	73.7415**
Location x cultivar	15	86.3707**
Year x location x cultivar	15	59.8347**
Harvest date x cultivar (year x loc.)	45	65.8373**
Error b	165	9.3971

**Mean squares are significant at .01 level of probability.

Peanuts dug at the early harvest date had slightly poorer milling quality than those dug later (Table 3). An examination of digging date means at individual locations within years revealed no consistent trend of superior milling quality with later digging dates (Table 4). For example, during 1976 milling quality for peanuts from the first digging date at Lewiston was better but milling quality of peanuts from the second digging date at Rocky Mount was better.

Table 2. Location and year means for milling quality.

Location	Year 1975	Year 1976	Mean
Lewiston	11.0a*	19.5a	13.8e
Rocky Mount	21.3b	17.8a	19.0f
Mean	13.0c	18.7d	

*Means with different letters significantly different at 0.05 level of probability. Letters a, b used for within-year comparisons; c, d for year means and e, f for location means.

Table 3. Means for milling quality for peanut cultivars and breeding lines averaged over years for two digging dates.

Cultivar/breeding line	Digging date 1	Digging date 2	Mean
NC 2	15.1	16.6	15.7
NC 4	10.2	9.3	9.8
NC 5	14.4	13.2	13.9
Florigiant	16.8	18.7	17.7
NC 17	18.5	20.3	19.3
NC-Fla 14	17.8	10.8	14.7
Va 72R	14.2	15.0	14.6
Avoca 11	18.3	10.0	14.6
Shulamit	17.0	15.1	16.2
NCBL (Ac 6333 x NC 5)	13.5	15.6	14.4
NC 6	13.7	10.6	12.3
NCBL (NC 5 x Florigiant)	16.4	12.8	14.8
NCBL (NC 5 x Ac 7484)	16.3	18.6	17.4
NC 7	21.9	13.2	18.0
NCBL (NC 5 x Florigiant)	16.2	21.3	18.5
NCBL (NC 5 x Va 61R)	16.8	16.9	16.9
Mean	16.1	14.9	15.6

Table 4. Means for milling quality for peanut cultivars and breeding lines for each location and digging date.

Cultivar/breeding line	1975 Lewiston 1	1975 Lewiston 2	1975 Rocky Mt. 1	1976 Lewiston 1	1976 Lewiston 2	1976 Rocky Mt. 1	1976 Rocky Mt. 2
NC 2	8.1	9.3	19.9	9.9	36.5	29.3	11.4
NC 4	7.5	7.1	10.7	7.6	16.7	17.6	6.5
NC 5	11.6	14.3	20.5	12.6	9.8	15.9	14.4
Florigiant	10.6	10.8	19.4	18.1	44.2	25.6	9.0
NC 17	12.3	12.6	33.1	13.7	41.1	21.3	15.1
NC-Fla 14	11.3	10.5	23.2	13.7	7.2	29.6	15.0
Va 72R	9.9	9.7	22.3	10.3	33.5	18.4	7.2
Avoca 11	8.7	8.6	28.7	12.9	12.4	32.6	10.2
Shulamit	11.3	11.0	19.3	16.6	26.2	26.8	12.5
NCBL (Ac 6333 x NC 5)	12.7	11.4	15.0	8.2	32.1	19.1	7.4
NC 6	11.0	10.3	16.3	10.3	13.2	20.2	8.5
NCBL (NC 5 x Florigiant)	11.2	12.2	22.4	12.0	15.7	25.4	11.1
NCBL (NC 5 x Ac 7484)	10.8	13.7	21.5	13.0	37.0	25.7	10.2
NC 7	14.0	13.5	26.6	18.2	16.6	36.7	9.1
NCBL (NC 5 x Florigiant)	8.7	12.3	18.3	18.3	42.8	27.2	18.1
NCBL (NC 5 x Va 61R)	11.8	12.7	24.5	11.3	32.8	24.8	9.5
Mean	10.7	11.2	21.3	12.9	26.1	24.8	10.9
LSD (.05)	1.9	1.9	10.4	4.8	12.6	9.8	4.6

The data clearly demonstrate that environmental factors influence the milling quality of peanuts. Milling quality tends to vary significantly depending upon a specific year, location and digging date combination.

Even with significant environmental influences and cultivar by environment interactions, differences among cultivars for milling quality were significant (Tables 1, 3, 4). NC 4 had the best milling quality over both early and late digging dates. It was the best cultivar for five of the seven individual tests (Table 4). NC 6 ranked second for milling quality averaged over all tests (Table 3). Evaluations of blanching and milling quality by industry before release of this cultivar indicated that NC 6 should have a low percentage of split and bald seeds since the testae are more difficult to remove than those of Florigiant (6).

Florigiant, the most widely grown cultivar in North Carolina and Virginia, had low milling quality in this study (Table 3). This was not surprising since Mozingo and Ashburn (6) found that the testa of Florigiant is easily removed during blanching. We have also observed that Florigiant has a loose fitting testa. This results in a relatively high percentage of split and bald seeds when Florigiant is shelled and processed.

The variability in milling quality observed among cultivars is obviously genetic. An analysis of milling quality data for progeny from the cross of NC 5 and Florigiant indicates that the genetic component affecting milling quality is large. The F_2 families for the reciprocal crosses of Florigiant and NC 5 were significantly different for milling quality when the F_6 progenies were evaluated after being grown in a single environment (Table 5). F_2 family means ranged from 4.92 to 13.43 for the cross of Florigiant x NC 5 and from 5.57 to 14.91 for the reciprocal cross (Table 6). This suggests that genotypes with desired levels of milling quality can be selected.

Table 5. Mean squares from analysis of variance of milling quality of F_6 generation for the cross of NC 5 and Florigiant and its reciprocal.

Source	df	Mean squares	
		Florigiant x NC 5	NC 5 x Florigiant
Rep	2	31.6935**	20.6272**
F_2	19	58.3451**	52.1249*
F_3 (F_2)	20	16.5318	22.1473**
F_4 (F_3, F_2)	40	15.5492*	8.2037
Error	158	9.9082	5.8967

*,**Indicates mean squares are significant at .05 and .01 probability levels, respectively.

Estimates of genetic variance were not larger than their associated standard deviations (Table 7). These results might be expected since the procedures used to estimate the variance components of mean squares is not very precise. A larger number of F_2 families and more replications of the individual F_6 generation lines would be required to give better estimates of the genetic variance for milling quality. Estimates of heritability for these crosses (0.63 for Florigiant x NC 5 and 0.78 for NC 5 x Florigiant) are moderately high although the large standard deviations associated with the variance components suggest that the confidence limits for the heritability estimates are also large. These estimates indicate that selection for milling quality based on means over replications in a single environment should be effective.

Table 6. F_2 family means for milling quality measured on F_6 progeny for the cross of NC 5 and Florigiant and its reciprocal.

F_2 family	Florigiant x NC 5	NC 5 x Florigiant
1	6.76	6.09
2	11.36	8.75
3	10.46	8.88
4	9.22	10.27
5	7.82	8.63
6	8.56	11.06
7	7.89	11.29
8	7.05	8.94
9	5.11	7.53
10	9.74	9.24
11	10.63	8.65
12	8.36	12.06
13	9.94	8.68
14	7.48	9.94
15	4.92	8.16
16	10.34	5.57
17	12.21	7.81
18	13.43	14.91
19	9.05	10.81
20	10.64	9.28
LSD (.05)	3.47	4.02

These studies demonstrate that differences among cultivars for milling quality can be measured using small samples and the sheller developed by Davidson and McIntosh (2). This study also suggests that selection for milling quality should be possible.

Table 7. Maximum likelihood estimates of variance components and their associated standard deviations for milling quality for the cross of Florigiant x NC 5 and its reciprocal.

Cross	Variance components		
	σ_e^2	σ_A^2	σ_{AA}^2
Florigiant x NC 5	10.27±1.12	5.38±5.69	0.54±5.94
NC 5 x Florigiant	5.84±0.65	4.37±5.08	2.39±5.02

Although cultivars with extremely good milling quality could probably be developed through breeding, the breeder will also need to evaluate and select for ease of blanching. The factors that contribute to good milling quality may lead to poor removal of skins. It will probably be necessary to measure blanching and milling quality and consider both traits simultaneously in selection of advanced breeding lines. Thus the breeder may be forced to select genotypes that compromise good milling and blanching quality. The genetic relationship of these two traits should be investigated in further studies.

Literature Cited

1. Barr, A. J., J. H. Goodnight, J. P. Sall, and J. T. Helwig. 1976. A User's Guide to SAS-76. SAS Institute, Inc., Raleigh, N.C.
2. Davidson, J. R., Jr., and F. P. McIntosh. 1973. Development of a small laboratory sheller for determining peanut milling quality. Jour. Amer. Peanut Res. Educ. Assoc., Inc. 5:95-108.
3. Hanson, W. D., and C. R. Weber. 1961. Resolution of genetic variability in self-pollinated species with an application to the soybean. Genetics 46:1425-1434.

4. McIntosh, F. P., J. I. Davidson, Jr., and R. S. Hutchison. 1971. Some methods for determining milling quality of farmers stock peanut. Jour. Amer. Peanut Res. Educ. Assoc., Inc. 3:43-51.
5. Mood, A. M., F. A. Graybill, and D. C. Goes. 1974. Introduction to the Theory of Statistics. McGraw-Hill Book Co., New York.
6. Mozingo, R. W., and R. D. Ashburn. 1977. Peanut variety and quality evaluation results 1976. Tidewater Research and Continuing Education Center Information Series No. 20, Suffolk, Virginia.
7. Woodward, J. D. 1973. The relationship of peanut milling quality to kernel tensile strength. Jour. Amer. Peanut Res. Educ. Assoc., Inc. 5:169-174.

Accepted February 8, 1982