EDITOR'S NOTE: This paper was printed in Vol 1 No. 2 issue of *Peanut Science* with the wrong tables. It is reprinted here in its correct form.

# Effects of Restoring Peanut Moisture with Aeration Before Shelling

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**ABSTRACT**

**Moisture was restored to peanuts with aeration at controlled relative humidities before shelling. Restoring peanut moisture from 5 to 8 percent wet basis did not significantly affect milling quality. Elevating peanut moisture to levels that benefited milling quality caused profuse mold contamination of the peanuts. Germination decreased as peanut moisture content (m.c.) increased. Remoisturization caused only small changes in most food quality parameters.**

Peanut m.c. has a major effect on milling quality as well as other quality factors (*1, 2, 3, 4, 7, 9*). Optimum m.c. for shelling is difficult to maintain, because peanut m.c. fluctuates with ambient conditions. Peanuts sometime dry to 6 percent m.c. or lower during storage. Shelling peanuts at low kernel moistures results in high percentages of skin slippage and split kernels (*1, 2, 3, 7*).

Davidson et al. (*4*), showed that better shelling outturns can be obtained if peanuts are not permitted to overdry but are shelled at intermediate m.c. (between 7 and 16 percent). Several investigators (*1, 2, 3, 7*) also reported that milling quality of overdried peanuts can be improved by restoring the kernel moisture. Generally, the tested method for restoring moisture entailed spraying the peanuts with measured quantities of water. None of the above mentioned research concerning adding moisture to peanuts was conducted using commercial-type shellers for milling quality evaluations. An official grade sheller was used in some of the shelling evaluations which does not always accurately describe shelling outturn from commercial-type shellers and is fairly insensitive to milling quality changes (*6*). None of the above research dealt with the effects of remoisturization on quality measurements other than milling quality.

The purpose of this research was to determine the effects on peanut quality of remoisturization by aerating peanuts with air at specified relative humidities before shelling.

## Materials and Methods

Tests were conducted at the National Peanut Research Laboratory, Dawson, Georgia, with two lots each of Spanish and Virginia peanuts. The two lots of Spanish peanuts had initial moisture contents of 7.2 and 7.0 percent wet basis (w.b.); Virginia, 5.6 and 5.2 percent. Both lots of the Virginia peanuts were of the same quality, but the two lots of Spanish peanuts were not of the same quality.

Each lot of peanuts was thoroughly mixed and divided into six, 300-pound test samples. Five of the samples were placed in separate 22-in. diameter x 8 ft bins for aeration. The remaining sample was bagged in burlap bags and placed in simulated bulk storage. Test treatments used to add moisture to the peanuts before shelling are explained below:

| Test no. | Test treatment |
|---|---|
| A-1 | Continuous aeration at 90 percent relative humidity (r.h.) |
| B-1 | Continuous aeration at 80 percent r.h. |
| C-1 | Continuous aeration at 70 percent r.h. |
| D-1 | Continuous aeration with ambient air |
| E-1 | Ambient aeration at above 70 percent r.h. |
| Control - 1 (burlap bags) | Stored in dry storage, without aeration |
| A-2, B-2 . . . Control - 2 | Repeat of A-1 through Control-1 with lot 2 peanuts following completion of aeration of A-1 through Control-1 |

The airflow rate on all tests with aeration was 3.3 cfm/$ft^3$ peanuts.

Figure 1 is a schematic of one of the humidity-controlled bins used to aerate Spanish peanuts. The r.h. of the air in the large plenum was maintained above 90 percent by a steam humidifier. Modulating dampers controlled by humidistats in the bin plenums allowed the high-humidity air to mix with ambient air in the correct proportions to obtain air with the desired r.h. A high-

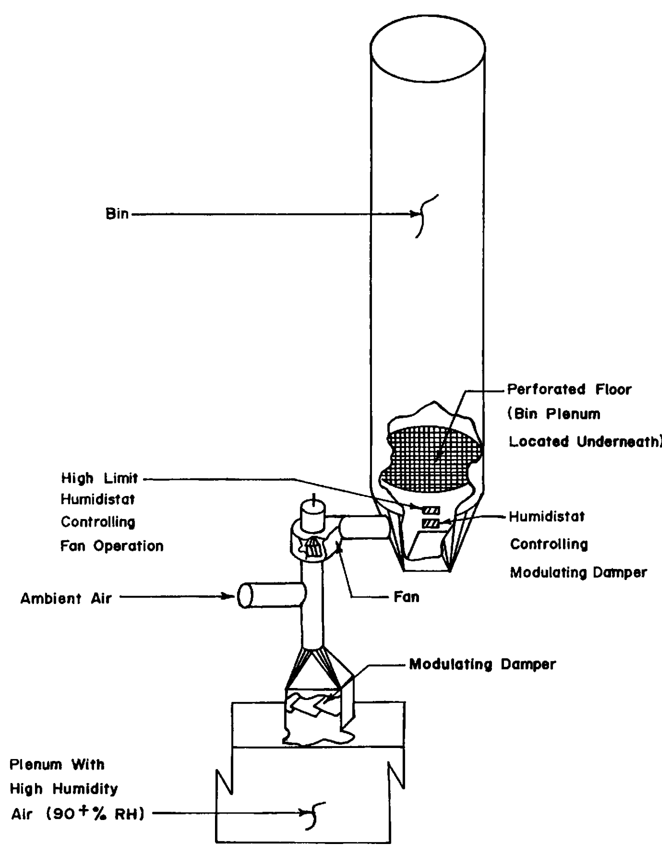


**Fig. 1. Schematic of one of the humidity controlled bins used to aerate the Spanish peanuts.**

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[2]Listing of manufacturers' or brand names does not imply that the Government recommends use or non-use of any product named in this paper.

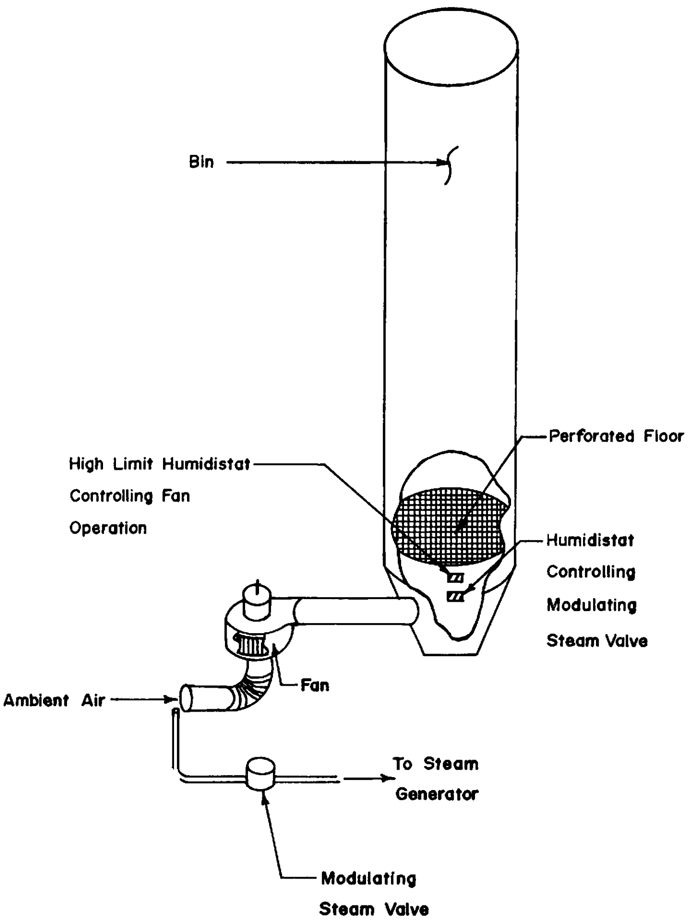


**Fig. 2. Schematic of one of the humidity controlled bins used to aerate the Virginia peanuts.**

limit humidistat discontinued fan operation at a predetermined humidity level. When ambient r.h. was above the humidistat setting, the fan did not operate.

Although this system provided reasonable control of the relative humidities, a different system was used for the tests on the Virginia peanuts (figure 2) in an attempt to gain better control of the relative humidities.

The major difference between this aeration system and the other was modulating steam valves metered steam directly into the air used for aeration. Required humidities were obtained with somewhat better control.

The m.c. of the peanuts in the top and bottom of each bin was checked daily with either an oven test or moisture meter. When kernel m.c. at the top and bottom of the humidity-controlled bins stabilized (after about 2 weeks), the peanuts were removed from all of the bins. Each sample was divided into 6 subsamples and shelled immediately with the laboratory shelling apparatus described by McIntosh et al. (6). Split and bald kernel outturns were considered the primary measure of milling quality.

Although the shelling apparatus used for these tests is actually a one-quarter size commercial-type sheller, it does not expose the peanuts to the amount of handling that is normally found in a commercial shelling plant. Nearly all bald kernels obtained from shelling with the apparatus will separate into split kernels when they are handled by shelling-plant equipment (6). Thus, split and bald kernel outturns obtained from the shelling tests were combined as expected split kernel outturn to show the percentage of split kernels expected from commercial shelling.

Since some variables that change peanut quality are generally magnified more in Virginia than in Spanish peanuts, samples from the shelled Virginia peanuts were examined to show the effects of remoisturization on germination and such food-quality parameters as flavor, color, iodine value, optical density, free fatty-acid content. and texture. Visibly molded kernels were removed before raw quality measurements were made. Internally damaged kernels were removed after roasting and blanching, and the peanut butter samples were analyzed for aflatoxin to protect taste panelists.

Samples of 400 sound, mature kernels were tested for germination. The kernels were treated with Ceresan-captan (ethyl mercury chloride + N-trichloromethyl thio-4-cyclohexene-1,2-dicarboximide) at a rate of 4 ounces per 100 pounds of peanuts, and placed in a germinator (95+ percent r.h., 30° C.) for 14 days. Kernels that developed secondary roots were considered viable.

Before being sampled for the food-quality measurements, the peanut kernels were redried to 5 percent m.c. (± 0.25 percent), as indicated by a Motomco[2] moisture meter.

The flavor of peanut butter made from 100 percent peanut kernels, which had been roasted, blanched, degermed, and ground to a fine smooth paste, was determined by averaging scores from 10 experienced taste panelists. Evaluations were made in individual masking-lighted booths, and samples were rated on a five-point hedonic scale, (excellent = 1 and very poor = 5). Flavor and color evaluation samples were roasted by a standardized procedure developed at the National Peanut Research Laboratory to maximize uniformity of roasting among samples of equal roasting potential. The first control subsample of the experiment was used to estimate optimum roasting conditions, which were than applied to all other samples as a basis for comparison of treatment effects upon roasting potential.

Color differences were measured in terms of Hunter "L" (darkness lightness) and "aL" ([ ] greenness [+] redness) values with a Hunterlab Model D25 Color and Color-Difference Meter. Four subsamples of raw kernels (skins intact) were measured and averaged and two subsamples of peanut butter were measured and averaged for each sample.

Iodine values and optical densities for samples of cold-pressed, raw peanut oil were obtained by procedures detailed in the report of the Peanut Quality Committee, 1971 Journal of APREA. Free fatty-acid percentages were measured by the A.O.C.S. official method Ca 5a-40.

A C. W. Brabender TEXTUR-O-METER measured peanut butter texture, using the following test conditions: small, star grooved, level-full sample platform of butter, at 75° F. (78° F. for the second series of tests); 2.5 mm-thick washer under-platform; sensitivity setting at 15 volts; chewing rate at 12 bites per minute with 18 mm-diameter lucite plunger; chart speed of 750 mm per minute. Force-time curves for the strokes of the plunger were analyzed as recommended by the manufacturer to derive the values for adhesivenss and cohesiveness of the peanut butter samples. However, the samples were not coated with powder, as is suggested, in order to isolate the cohesiveness measurement from the effects of adhesiveness with sticky materials.

# Results

## AERATION EQUIPMENT PERFORMANCE

Performances of the aeration systems in maintaining the incoming air at the required relative humidities for the tests on both the Spanish and Virginia peanuts are shown in tables 1 and 2, respectively. The system used for Virginia peanuts maintained average relative humidities within ± 5 percent more of the time (89.9 percent) than did the system used for Spanish peanuts (83.8 percent).

Final moisture contents of the peanut kernels and hulls are shown in tables 1 and 2. Average m.c. for the Spanish peanuts ranged from 7.38 to 12.37 percent and from 12.07 to 18.67 percent for the kernel and hull tests, respectively. The m.c. for the Virginia peanuts ranged from 6.5 to 14.8

Table 1. Performance of the aeration system during the tests on the Spanish peanuts.

| Test number | Average r.h. | Time average r.h. was maintained {± 5 percent} | Average m.c. {w.b.}1/ Kernels | Hulls |
|---|---|---|---|---|
| | Percent | Percent | Percent | Percent |
| A-1 | 81 | 84 | 9.97 | 16.4 |
| A-2 | 84 | 80 | 12.37 | 18.67 |
| B-1 | 71 | 84 | 8.27 | 13.63 |
| B-2 | 71 | 94 | 8.40 | 14.10 |
| C-1 | 62 | 72 | 7.44 | 12.07 |
| C-2 | 63 | 89 | 7.38 | 14.45 |

1/ Moisture content is w.b. as determined by the equation:

$$\text{Percent moisture \{wet basis\}} = \frac{\text{weight of moisture}}{\text{weight of wet material}} \times 100$$

Table 2. Performance of the aeration system during the tests on the Virginia peanuts.

| Test number | Average r.h. | Time average r.h. was maintained {± 5 percent} | Average m.c. {w.b.} Kernels | Hulls |
|---|---|---|---|---|
| | Percent | Percent | Percent | Percent |
| A-1 | 86 | 96.4 | 14.8 | 17.6 |
| A-2 | 90 | 98.6 | 13.6 | 16.7 |
| B-1 | 77 | 85.5 | 10.1 | 14.6 |
| B-2 | 82 | 88.1 | 9.7 | 15.7 |
| C-1 | 64 | 88.9 | 6.5 | 11.1 |
| C-2 | 69 | 81.6 | 7.6 | 10.8 |

percent and from 10.8 to 17.6 percent for the kernel and hull tests, respectively. Although the peanuts had not reached absolute equilibrium when removed from the bins, daily m.c. changes for kernels in the top and bottom of the bins had become negligible.

## Milling Quality

Average kernel moistures, split kernels, bald kernels, and expected split kernels, as well as statistical analysis of the data for Spanish peanuts are shown in table 3. Although Spanish peanuts for the two series of tests came from different quality lots and the data could not be combined for analysis, both series had the same general trends.

Split kernel outturn for both series varied inversely with kernel m.c.—as m.c. increased, split kernel outturn decreased. Increases in kernel moisture contents of 2.75 percentage points above the controls for the first series of tests and of 5.42 percentage points for the second reduced split kernel outturns by 5.90 and 6.24 percentage points, respectively (table 3). Except for one test in the second series, outturn of bald kernels was lower for the controls than for peanuts with higher m.c.

In both test series, peanuts in tests with the highest moisture contents had significantly lower expected split kernel outturns. Although the peanuts in several tests had significantly higher m.c. than the controls, only those with highest m.c. in each test series yielded expected split kernel outturns either statistically higher or no different from the controls. Thus, except for peanuts in tests with the highest moisture contents, increased m.c. did not restore milling quality of Spanish peanuts.

Table 3. The effect on the m.c. of the Spanish peanuts by aeration at different relative humidities.

| Test number | Average1/ kernel moisture | Average1/ split kernels | Average1/ bald kernels | Average1/ expected split kernels |
|---|---|---|---|---|
| | Percent | Percent | Percent | Percent |
| First series | | | | |
| A-1 | 9.97 d | 6.47 a | 8.20 bc | 14.67 a |
| B-1 | 8.27 c | 10.25 b | 9.83 d | 20.09 bc |
| C-1 | 7.44 ab | 12.50 d | 8.47 c | 20.97 c |
| D-1 | 7.29 a | 12.38 d | 7.54 ab | 19.93 bc |
| E-1 | 7.59 b | 11.87 c | 8.44 c | 20.31 bc |
| Control-1 | 7.22 a | 12.37 d | 6.91 a | 19.28 b |
| Second series | | | | |
| A-2 | 12.37 j | 6.26 g | 6.83 g | 13.09 g |
| B-2 | 8.40 i | 10.77 h | 11.69 j | 22.46 i |
| C-2 | 7.38 h | 12.18 i | 10.11 i | 22.29 i |
| D-2 | 7.63 h | 12.17 i | 10.45 i | 22.61 i |
| E-2 | 8.44 i | 10.95 h | 10.82 i | 21.77 hi |
| Control-2 | 6.95 g | 12.50 i | 8.33 h | 20.83 h |

1/ Averages followed by the same letter are not significantly different at the 5 percent level.

$$\textbf{Percent moisture (wet basis)} = \frac{\textbf{weight of moisture}}{\textbf{weight of wet material}} \times 100$$

Figure 3 shows the effect of kernel remoisturizing on percent split kernel outturn for Virginia peanuts. A difference of 8.2 percentage points in split kernels was obtained for the 5 to 15 percent m.c. range.

Bald kernel outturn vs. m.c. for Virginia peanuts is shown in figure 4. Bald kernels increased by 5.5 percentage points for moisture contents up to 9 percent and decreased by 11.9 percentage points for moisture contents between 9 and 15 percent.

Percent expected split kernel outturn is shown in figure 5. For the 5 to 16 percent m.c. range,

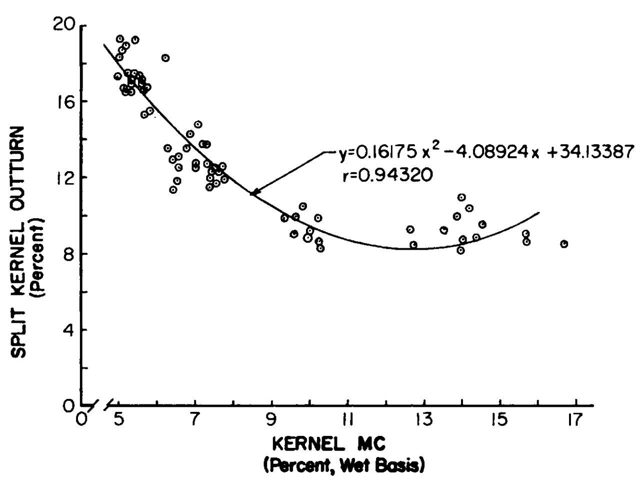


Fig. 3. The effect of kernel remoisturizing on the percent split kernel outturn for the Virginia peanuts.

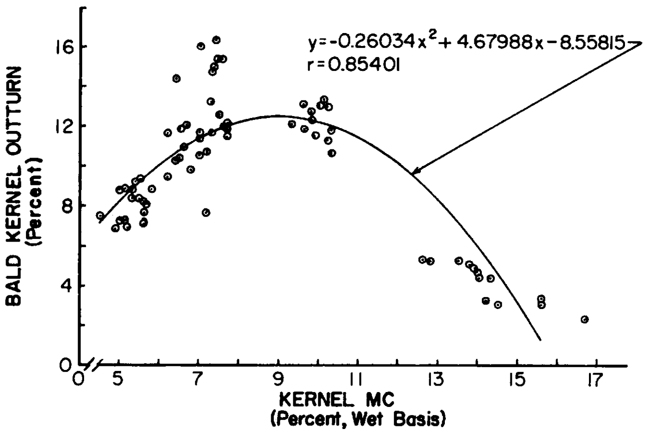


**Fig. 4. The effect of kernel m.c. on bald kernel outturn for the Virginia peanuts.**

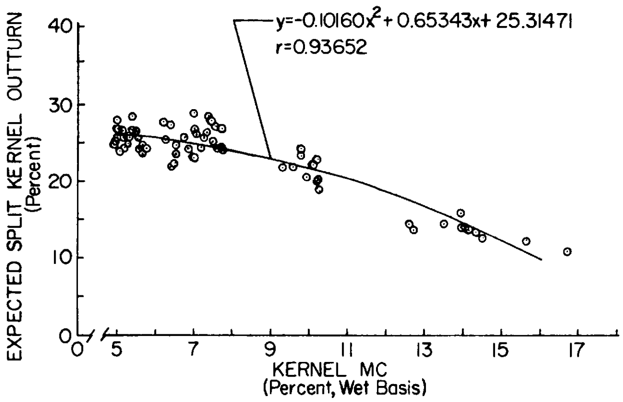


**Fig. 5. The effect of kernel m.c. on the expected split kernel outturn for the Virginia peanuts.**

expected split kernel outturns varied 16.3 percentage points. Peanuts with kernel moisture contents higher than 8 percent became moldy and inedible.

When the data for the peanuts below 8 percent m.c. were analyzed, no correlation was found between m.c. and expected split kernel outturn. Thus, like the Spanish peanut tests, increasing kernel m.c. to the safe storage upper limit of 8 percent did not restore the milling quality of Virginia peanuts.

## Germination

Results of the germination tests on the Virginia peanuts are presented in table 4. Generally, the percentage of germinated kernels decreased as m.c. increased. With each low percentage of germination a high percentage of kernels were rejected because of mold contamination during the germination tests. Less than 1.4 percent of the peanuts were rejected because they were nonviable.

## Food Quality Parameters

To assign values to various food quality parameters, we averaged treatment score values for samples taken from the tops and bottoms of treatment bins for each of the two test series (replications). Values for controls are not averages because the controls were stored in burlap bags and provided a single representative sample for each replication. Duncan's New Multiple-Range Test (8) was used to separate statistically different (5 percent level) treatment means for each food-quality parameter. Table 5 shows five parameters that demonstrated significant differences among treatment means.

Variation among mean scores for flavor was just barely significant at the 5 percent level. The highest remoisturizing treatment (treatment "A") received the poorest rating, although it was not statistically different from the control.

Red coloration of the raw peanut skin was significantly less for kernels of treatment "A" than for any other treatment or the control, as indicated by Raw Kernel Color, "aL". The difference may have been too small for practical significance; however, retduction of red coloring might be considered a slight advantage for peanuts darkened by long-term storage.

Peanuts from treatment "A" that were processed into butter had a lower "aL" reading and would have required longer or hotter roasting to achieve color uniformity with the control or other treatments.

**Table 4. The effect on the m.c. of the Virginia peanuts by aeration at different relative humidities.**

| Test number | Average m.c. | Germinated kernels | Molded kernels | Nonviable kernels |
|---|---|---|---|---|
| | Percent | Percent | Percent | Percent |
| A-1 | 14.8 | 26.4 | 73.0 | 0.6 |
| A-2 | 13.6 | 7.7 | 92.3 | 0 |
| B-1 | 10.1 | 53.8 | 45.8 | 0.4 |
| B-2 | 9.7 | 68.4 | 30.9 | 0.7 |
| C-1 | 6.5 | 71.5 | 28.3 | 0.2 |
| C-2 | 7.6 | 80.2 | 19.8 | 0 |
| D-1 | 5.1 | 57.8 | 42.0 | 0.2 |
| D-2 | 5.5 | 79.9 | 18.7 | 1.4 |
| E-1 | 7.5 | 79.5 | 20.3 | 0.2 |
| E-2 | 7.0 | 79.4 | 20.0 | 0.6 |
| Control -1 | 5.6 | 1/ | 1/ | 1/ |
| Control -2 | 5.2 | 72.3 | 27.0 | 0.7 |

1 Lost sample

**Table 5. Average kernel m.c. and percentage of split kernels, bald kernels, and expected split kernels for the Spanish peanuts.**

| Test number | Quality parameters, treatment mean values | | | | |
|---|---|---|---|---|---|
| | Flavor | Raw kernel color "$a_L$" | Peanut butter color "$a_L$" | Iodine value | Optican density of oil, 450 mu |
| A-1 and A-2 | 2.60 a | 13.14 a | 7.26 a | 89.77 a | 0.0116 a |
| B-1 and B-2 | 2.15 ab | 14.03 b | 8.03 b | 90.20 bc | 0.0656 b |
| C-1 and C-2 | 2.00 b | 14.08 b | 8.85 b | 90.29 cd | 0.0671 b |
| D-1 and D-2 | 2.43 ab | 14.04 b | 9.21 b | 90.26 bcd | 0.0563 b |
| E-1 and E-2 | 2.00 b | 14.11 b | 8.72 b | 90.38 d | 0.0581 b |
| Control-1 and Control-2 | 2.30 ab | 13.86 b | 8.73 b | 90.12 b | 0.0512 b |

1/ Treatment means not followed by the same letter are significantly different from each other at the 5-percent level (8).

Iodine value for treatment "A" peanuts was also lower than the others, which might forecast a somewhat longer shelf life. This again is a statistical difference of questionable practical size.

Pigmentation of oil from all samples seems exceptionally low and was probably the result of long-term storage under ambient conditions before treatment and shelling. Nevertheless, optical density measurement indicates yellow pigmentation significantly lower for treatment"A" than for any other treatment or for the control. If peanuts with highly pigmented oil respond with a similar degree of "bleaching," treatment "A" might be considered as a method for bleaching oil of oilstock peanuts before shelling and extraction.

Table 6 presents data on five food-quality parameters not significantly affected by remoisturizing as determined by Duncan's New Multiple-Range Test. Some of these parameters were not statistically significant for treatment effects because of wide variations between replications; others because of the small number of replications. The adhesiveness (stickiness) measurement is a prime example of wide variation between replications. Butter from treatment "A" peanuts was the least adhesive in both replications, yet not statistically so. A two-way analysis of variance on the data also failed to show significant differences among treatments, but it did show a 2.5 percent level of significance between replications.

In both replications the Hunter "L" value for treatment "A" peanut butter was higher (lighter) than other samples, as expected because of the significantly lower "aL" values (less red) of treatment "A" samples. However, the lower "L" values for raw kernel color in treatment "A" were not expected because of their significantly lower "aL" value. With this combination of color parameters, "duller" (less reflective) is more descriptive for the skin color of treatment "A" raw kernels than "darker" (low "L") or "less red" (low "aL").

Percentages of free fatty acids were at "safe" levels for most samples of the study. However, both replications of treatment "A" samples had the highest levels, and the level in replication "2" appeared high enough (1.125 percent) to downgrade its flavor rating (2.90).

**Table 6. Average kernel m.c. and percentage of germinated, molded, and nonviable kernels for the Virginia peanuts.**

| Test number | Quality parameters, replication mean values | | | | |
|---|---|---|---|---|---|
| | Raw kernel color "L" | Butter color "L" | Free fatty acids | Adhesiveness | Cohesiveness |
| | | | Percent | | |
| A-1 | 38.96 | 49.43 | 0.300 | 0.85 | 1.0115 |
| A-2 | 39.04 | 53.10 | 1.125 | 0.75 | 1.0555 |
| B-1 | 39.18 | 49.22 | 0.150 | 0.95 | 1.0000 |
| B-2 | 39.77 | 50.20 | o.175 | 1.30 | 0.8945 |
| C-1 | 39.70 | 46.35 | 0.125 | 0.95 | 1.0905 |
| C-2 | 39.52 | 48.32 | 0.200 | 1.45 | 0.9210 |
| D-1 | 39.70 | 45.13 | 0.125 | 1.05 | 0.9655 |
| D-2 | 39.72 | 46.85 | 0.150 | 1.45 | 1.0300 |
| E-1 | 39.43 | 47.75 | 0.250 | 1.00 | 1.0710 |
| E-2 | 40.19 | 47.88 | 0.150 | 1.65 | 1.0270 |
| Control-1 | 40.46 | 48.34 | 0.100 | 1.00 | 1.0770 |
| Control-2 | 39.82 | 46.66 | 0.150 | 1.80 | 0.9440 |

1/ Statistical signifacance at the 5 percent level, as determined by Duncan's new multiple-range test [8].

# Discussion

Several investigators have reported that milling quality of overdried peanuts may be restored by adding moisture to the peanuts. However, this and other in-house (unpublished) studies indicate that remoisturizing farmers stock peanuts (from 5 to 8 percent wet basis) does not significantly affect milling quality. Remoisturizing farmers stock peanuts to above 8 percent m.c. involves a high risk of mold contamination and is not recommended, especially when high-humidity aeration systems, such as those described in this report, are used.

Disagreement between these results and those reported in literature probably resulted from differences in the shellers used (commercial-type shellers in this study, laboratory shellers in previous studies) and different criteria used in determining milling quality. Apparently, the effects of restoring moisture on bald kernel outturn was not detected in previous studies, but should be emphasized because, within the 5 to 8 percent kernel m.c. range, increases in bald kernels will generally offset apparent benefits of reducing the split kernel outturns.

Quality measurements other than milling quality were also affected by this method of adding moisture to low moisture peanuts. Percentage of germinated kernels decreased as the kernel m.c. increased. This factor was related to increased susceptibility of the peanuts to mold contamination. Small changes in food-quality parameters were related to remoisturization, and the treatment that restored the most moisture was the one that produced the most changes.

In summary, restoring peanut moisture with aeration before shelling produces undesirable results and is not recommended by the authors. Once milling quality has deteriorated because of moisture loss, quality will not be improved by restoring moisture to levels that are low enough to avoid mold growth. Milling quality should be maintained by maintaining m.c. at desirable levels during storage instead of adding moisture just before shelling (*10*).

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