Drying Spanish Peanut Pods with Short Duration, High Temperature Air Cycled Daily[1]

R. A. Rogers and G. H. Brusewitz[2]

ABSTRACT

Freshly harvested Spanish peanut pods were dried with three different treatments in a controlled temperature and humidity environment. Each treatment included a different combination of temperature above 35°C and time held above this temperature. This procedure, or cycle of time and temperature, was repeated every 24 hours until a wet basis moisture content of approximately 10% was reached. A statistical analysis was conducted to determine whether or not there was any significant difference between treatments. At the 0.1 level of significance, statistical difference between treatments could not be shown. However, on the average, high temperature drying affected the percentage splits more than rate of drying. Splits also seemed to be affected more by temperature level than by exposure length. Findings relating to peanut quality are subject to large experimental error due to variations in variety, climatic and soil conditions, and maturity. Comparison of percentage sound splits was more meaningful when corrected for grade.

Keywords: drying, peanuts, high temperature, quality.

The moisture content of peanut pods, after harvesting and before storage, must be reduced to approximately 10%. Storage at higher moisture contents provides an environment favorable to mold growth and insect attack. The most common method of reducing moisture content is to add supplemental heat to the air forced through peanuts placed in deep bed dryers. Currently a major portion of the peanuts dried in the Southwest are dried at commercial installations. Due to heavy demands placed on commercial dryers during peak harvest periods, maximum recommended drying temperature is often exceeded and a decrease in peanut quality results. The maximum constant drying temperature is generally accepted as 35°C.

As a result of these quality losses some farmers continue to sack dry in the field. The main concerns with sack drying are uncontrollable weather conditions, time required to dry, and high labor requirements. During unfavorable weather conditions, peanut pods may not dry below 20% moisture content.

Researchers from the USDA Agricultural Research Station at Tifton, Georgia (Butler, 1969), found that peanut pods reached temperatures of 49°C or higher for three hours or more per day under good field drying conditions. Troeger (1972) found that cycling periodic high and low temperatures reduces drying time (compared to constant 35°C drying) and increases split kernel percentage without affecting flavor. This research was conducted in Georgia where the humidity during the harvest season is high compared to that in the Southwest.

The objective of this study was to compare the (1) drying time, and, (2) quality of peanuts dried with temperatures periodically higher than 35°C in various time-temperature combinations.

Materials and Methods

Spanish peanuts were secured from the Oklahoma State University Agricultural Research Station near Stratford, Oklahoma, and placed in drying bins constructed of steel drums which were capable of holding from 45 to 55 kilograms of wet peanuts. The bins were placed on platform scales so that an average moisture content could be determined by the change in weight as the peanut pods dried. The drying air temperature and humidity was controlled by an Aminco environment chamber. Final moisture content was determined by oven drying a sample at 130° C for approximately 12 hours.

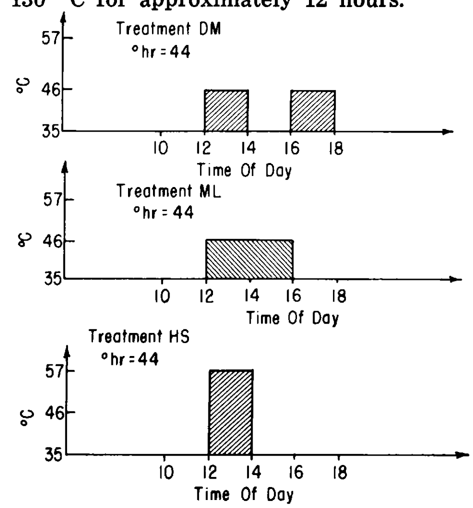

Fig. 1. Experimental Design.

Figure 1 shows the three different treatments used in this study. A medium temperature rise occuring twice a day (treatment DM), a medium temperature rise occuring once a day but for a longer period ((treatment ML) and high temperature rise occuring once a day for a short time (treatment HS) were the three treatments used in this study. In all treatments, the combination of temperature greater than 35° C and time held above 35° C (defined as the degree-hours) was the same for all tests. This was done in an effort to determine whether or not the manner in which the degree hours was obtained had any significant effect on peanut milling quality.

The peanuts were placed in drying bins approximately one meter deep. Initial relative humidity of the drying air was 37% and decreased as the dry bulb temperature increased. The flow rate was a constant 14 cubic meters per minute per square meter throughout the tests and initial moisture contents ranged from 21.9% to 30.0% wet basis. Three replications were made of each treat-

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[2]Formerly Graduate Research Assistant and Associate Professor, respectively, Agricultural Engineering Department, Oklahoma State University, Stillwater, Oklahoma 74074.

ment and samples were taken from each replication to be graded.

As the peanuts were brought in from the field, a standard was taken from each lot. The standard was dried in a laboratory dryer which consisted of electrical resistant heaters that heated the room air and forced it through peanuts one layer deep. An effort was made to keep damage due to drying at a minimum; therefore, the temperature was not allowed to exceed 35° C. However, if dried too slow mold would form on the peanuts. The temperatures for drying the standards varied from 24° C to 35° C and the peanuts were taken from the dryer whenever wet basis moisture content reached approximately 10%. Since the peanuts were dried at such varying temperatures, the time required to dry varied greatly. Due to this the standards could be used when comparing splits of various treatments, but not for comparing drying times.

After drying was completed, the pods were stored in a cooler at approximately 4° C until shelling tests could be performed. At the end of the drying season, pods were removed from cold storage, pre-sized and shelled according to United States Department of Agriculture (USDA) grading procedure.

Results and Discussion

Quality Analysis

As the research progressed it was noted that splits seemed to be affected by USDA grade (defined as percent sound splits plus percent sound mature kernels). Figure 2 is a graph depicting

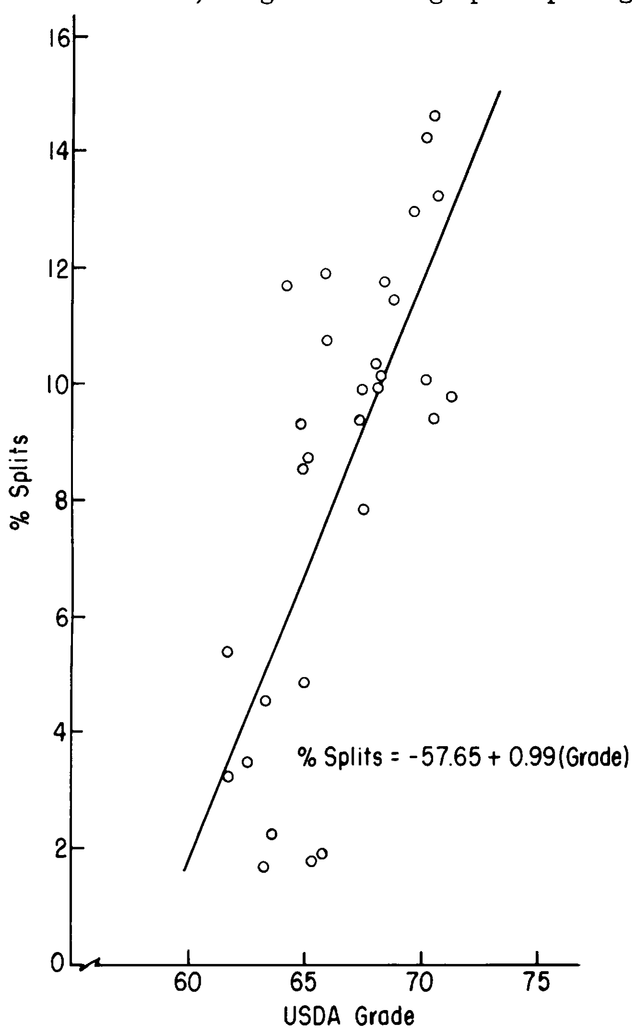

Fig. 2. Effect of Grade on Percent Splits.

splits versus USDA grade. Since this could cause an error in determining percent sound splits, a new variable SSR was defined as 100 times the percent sound splits divided by grade.

Since final moisture content has a large influence on percent sound splits, it was desired to dry each treatment to the same kernel final moisture content wet basis. This was not precisely achieved because only an estimate of the final moisture content could be determined while the peanuts were in the drying bins. To correct for this a least squares regression was run on each treatment and a common slope found. Once a common slope was found, this regression equation [1] was used to correct all final moisture contents to an arbitrary 9% wet basis.

$$SSR = 33.24 - 2.86\ (FMC) \qquad [1]$$

where

SSR = Sound split ration = (percentage of splits grade) × 100

FMC = Percent final moisture content of kernels wet basis

By using 9% as a basis of comparison and equation [1], it was possible to adjust all treatments to the same final moisture content and at the same time preserve their deviations from one another. Equation [2] is the final correction equation developed to correct for final moisture content and grade.

$$SSAJ = SSR - 2.86\ (FMC) - 25.72 \qquad [2]$$

where

SSAJ = Percent sound splits adjusted for grade and final moisture content

SSR = Sound split ratio = (percentage of splits/grade) × 100

FMC = Percent final moisture content of kernels wet basis

Two methods were used to test for statistically significant differences between treatments. Initially, a difference between treatment means with unknown and unequal population variance was used (Remington and Schork, 1970). An inspection of these results (Table I) indicate a

Table 1. Test of significant difference in splits between treatment means.

Compared Treatments		t-Cal.	t-Tab. (0.1)	Confidence Interval (90%)
DM	ML	-1.449	1.761	0.350 -3.600
DM	HS	-3.341	1.796	-1.537 -5.111
DM	STANDARD	-2.601	1.746	-0.645 -3.277
ML	HS	-1.368	1.753	1.003 -4.401
ML	STANDARD	-0.318	1.796	1.565 -2.237
HS	STANDARD	1.476	1.812	3.036 -0.310

statistical difference (at the 90% confidence level) between treatments DM and HS and between DM and Standard.

The second procedure used to test for significant difference was an analysis of variance (AOV). As shown in Table II, no statistical significance (at the 0.1 level) could be shown between treatments. However, significant difference between runs was shown. This says that experimental error was greater than sampling error. This is not unexpected because experimental error is affected by variation among peanuts treated alike and variation of peanuts for different treatments. If peanuts did not vary from lot to lot, then the order of magnitude of the two variations mean squares should be the same and experimental error would not be expected to be larger than sampling error. Since peanuts can vary from lot to lot because of different growing conditions, harvesting conditions, and other uncontrollable factors, the experimental error (not unexpectantly) was greater than the sampling error.

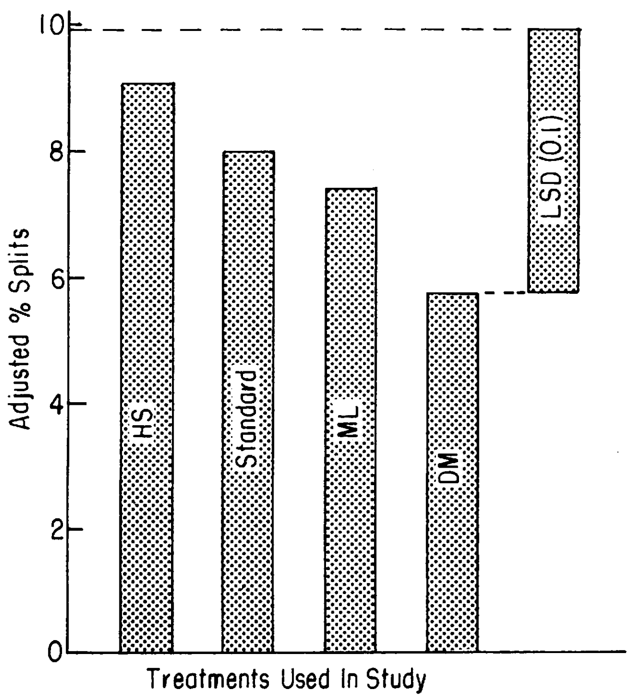

Fig. 3. Effect of Treatment on Adjusted Percent Splits, and the Statistically Determined Least Significant Difference. LSD (0.1) = 4.164. Standard Deviations are: DM = 1.45, ML = 2.85, Standard = 1.97, and HS = 1.96.

Figure 3 is a graphical representation of the AOV results. As can be seen by observing the least significant difference (LSD), significant difference between treatments cannot be shown. The least significant difference is a statistical method of determining how great the difference between observed means must be in order to be statistically significant.

When considering the standard in Figure 3 the manner in which they were dried should be remembered. The Materials and Methods section explained how the standards were dried. During peanut harvest time in the Southwest relative humidities may be quite low. Relative humidity in the room used to dry standards was at times below those used to dry the tested treatments. Because of this it is possible that drying rates for the standards exceeded those for the treatments.

DRYING ANALYSIS

Since each lot of peanuts had a different initial moisture content and equivalent final moisture contents were not achieved, a moisture ratio was used in comparing drying times. The moisture ratio is defined by equation [3].

$$MR = \frac{MC - ME}{MI - ME} \quad [3]$$

where

MR = Moisture ratio

MC = Percent moisture content dry basis at any desired time

ME = Percent equilibrium moisture content dry basis (function of air relative humidity and air temperature)

MI = Percent initial moisture content dry basis

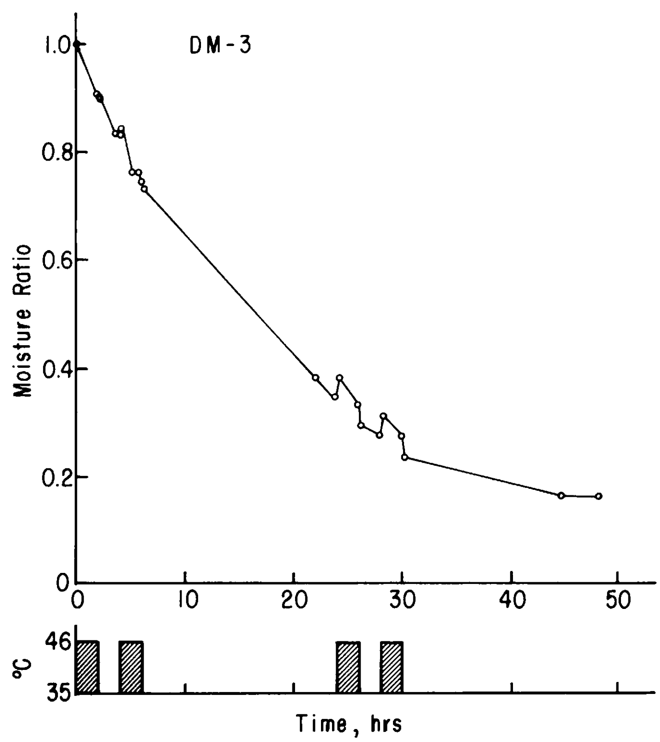

Fig. 4. Effect of High Temperature Cycling on Moisture Ratio for Run DM-3. Note: Breaks or Discontinuities are Caused by Increasing Drying Air Temperature and Resulting Decrease in the Equilibrium Moisture Content.

Figure 4 is an example of how moisture ratio is affected by cycling drying temperatures. Whenever a dry bulb temperature increase occurs, the equilibrium moisture content decreases resulting in an increase in the moisture ratio.

Figure 5 is an example of how drying rate is affected by cyclic drying temperatures. As shown,

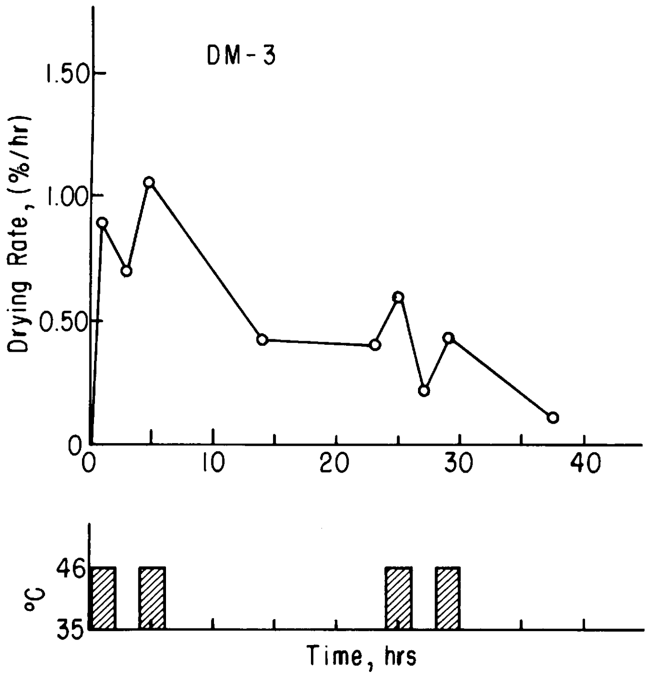

Fig. 5. Effect of High Temperature Cycling on Drying Rate for Run DM-3.

the drying rate increased when drying temperature increased. These drying rates were determined by averaging the amount of moisture lost between readings taken during drying.

A difference between means analysis and an AOV analysis were run to determine whether there was significant difference between average drying rates. These average drying rates were determined by taking the amount of moisture lost in drying from initial moisture content (dry basis) to a moisture ratio of 0.3 and dividing by the time required to accomplish this. Both the difference between means analysis and AOV (Rogers, 1976) showed no significant difference (at 90% confidence level) between treatment drying rates (Figure 6).

Even though no significant difference between treatments could be shown, it was noted that the highest temperature treatment (treatment HS) had the highest average percent splits and lowest average drying rate. This treatment is likely to be commercially unacceptable. Treatment DM, with two small temperature rises, had the least effect on either splits or drying rate. Treatments DM and ML at 46°C were not statistically different for either quality or drying time and could possibly be commercially acceptable. These results compare to the findings of Farouk (1967).

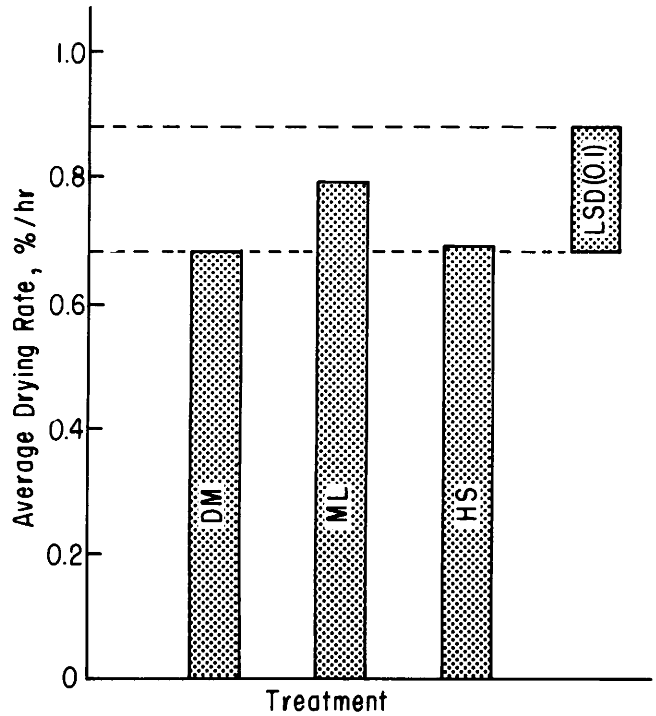

Fig. 6. Average Drying Rate from Moisture Ratio of 1.0 to 0.3 and the LSD (0.1) = 0.2. Standard Deviations are: DM = 0.052, ML = 0.144, and HS = 0.005.

Summary and Conclusions

This study was concerned with drying peanut pods with temperatures periodically greater than 35°C and determining the effect on quality and drying time. After drying to approximately 10% moisture wet basis, the pods were shelled and USDA grade factors were determined.

The results were not as conclusive as expected for the following reasons: (1) Experiments relating to peanut quality are subject to large experimental error due to variations in variety, climatic and soil conditions, and maturity, (2) Final moisture content is difficult to control due to continued transfer of moisture from kernel to hull after drying is stopped, and (3) Experimental error may have masked statistical significant differences between treatments.

The conclusions that were reached from this study were:

(1) Temperature affects splits more than drying rate, (2) Splits are affected more by temperature level than by length of exposure, and, (3) Comparisons of percentage sound splits are more meaningful when corrected for USDA grade.

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