Some Moisture Related Properties of Spanish Peanuts

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ABSTRACT

Physical properties of Spanish-type peanuts (Starr variety) related to moisture content were measured, including apparent density (AD), solid density (SD), void fraction (VF), solid volume per nut (SVN), and total volume per nut (TVN). Measurements were taken on hulls, kernels and whole peanuts, at moisture contents from 0 to approximately 30% wet basis. Test samples were rewet rather than fresh. Data were plotted vs. moisture content in each case and best fit regression equations were developed. VF for kernels was less than VF for whole peanuts which was less than VF for hulls, as expected. TVN for hulls plus kernels compared to TVN for whole peanuts indicates that the kernel cavity is completely filled at approximately 31% m. c. AD and VF relations between hulls, kernels and whole peanuts indicate that swollen kernels may tend to compress the inner layers of the hull at high m. c. Hull wet weight was about 26% of kernel wet weight and hull m. c. about 6% greater than kernel m. c. SVN for hulls was very small (0.08 cc/nut average) and apparently unrelated to m. c. SD for hulls was quite high—1.5 to 4.5 gm/cc.

Future design of processing equipment for peanuts will require a more complete knowledge of their physical properties. This is particularly true for moisture related properties since drying is a major part of processing. Dickens and Pattee (1972) gave a comprehensive review and bibliography of the gross effects of current drying practices on final product quality. More advanced work on internal vapor diffussion in peanuts (Young and Whitaker 1971, Whitaker and Young 1972a, b) and on alternative methods of drying such as use of radio-frequency energy (Wright and Porterfield 1971) and spouted beds (Nelson and Gay 1971) will, however, require additional knowledge of moisture related properties as experiment approaches application. Recent examples of the determination of such properties include dielectric constant (Whitney and Porterfield 1967), specific heat (Wright and Porterfield 1970), heat of respiration (Brusewitz and Hamilton 1972, Suter and Clary 1973) and other thermal properties (Suter, Agrawal, and Clary 1972).

The properties reported in this paper are primarily concerned with densities, volumes, and void fractions of whole spanish-type peanuts, hulls and kernels as related to moisture content.

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Experimental Procedures

DEFINITIONS

Hulls — the fibrous outer case of the peanut, sometimes referred to as "pods" in other papers

Kernels — the peanut seeds including the skin covering. All peanuts used in these tests had two kernels. Results for kernels are reported here on a per nut (two kernel) basis.

TVN — total volume per nut. This includes the total space enclosed by the outer surfaces of the object being measured—either hulls, kernels, or whole peanuts.

SVN — solid volume per nut. This is the volume of solid material plus discontinuous pore space of the object being measured. The discontinuous pore space is assumed to be quite small relative to the continuous pore space. There does not yet appear to be any convenient means of determining discontinuous pore space.

VF — (TVN — SVN)/TVN, or void fraction. This is the continuous pore space.

SD — wet weight per nut/SVN, or solid density. This is the density of the solid material plus discontinuous pore space of the object being measured.

AD — wet weight per nut/TVN, or apparent density.

MC — moisture content, wet basis.

HWW, KWW — hull and kernel wet weights, respectively.

HMC, KMC — hull and kernel moisture contents, respectively.

PROCEDURE

Eight large samples, 500-600 grams each, were drawn from a lot of spanish peanuts (Starr variety) and dried for 16 hours at 200°F in a forced draft oven. The eight samples were then weighed and transferred to quart containers. Two of the containers were sealed immediately for use in those tests at zero moisture content.

The other six containers were arranged in pairs and enough water was added to bring each pair to the nominal moisture contents of 12.1, 21.6, and 29.2% wet basis. All calculations were subsequently made on wet basis. A small amount of powdered fungicide was added to each container to prevent mold growth.

Field observations at harvest time indicated that fully developed spanish peanuts had average moisture contents of approximately 30% w. b. This value was therefore chosen as the maximum moisture content for these tests.

Care was taken in applying the required amounts of water to the samples to insure that all nuts were evenly wetted. The samples were sealed in their containers and allowed to equilibrate at ambient temperatures for 10 days. They were stirred two or three times daily during this period by shaking the containers.

One set of tests was run on whole peanuts. Ten samples of 20 nuts each were extracted from the large samples at each of the four nominal moisture contents and tested. A second set of tests was run on kernels and hulls. In these tests 5 samples of 20 nuts each from each of the four nominal moisture contents were used. The kernels and hulls were separated by hand and tested separately.

Solid volume data on the samples were taken with an air comparison mercury column picnometer (±0.1 ml. accuracy). Total volume data on the samples were taken by the liquid displacement method. The liquid used was toluene with a specific gravity of 0.866. The volumetric flask used had an accuracy of ± 0.1 ml. Samples were weighed before and after these tests on a Mettler balance (± 0.0001 gr.) and data were corrected for the amount of toluene absorbed during the tests. Each sample was dried after all testing was completed at 200°F for 16 hours in a forced draft oven and weighed again to determine its exact moisture content.

Results and Discussion

Figures 1 through 17 depict the results of the tests. Best-fit equations were determined for each data set using a non-linear curve-fit computer program. Equations tested in each case were chosen for simplicity and ease of use rather than maximum correlation (for instance, no equation of higher than second degree was tried). Similarly, no attempt was made to force the test equations through an assumed upper limit of any property at 100% moisture content.

One of the more important properties for vapor diffusion studies is void fraction (VF). VF for kernels (Fig. 3) was less than that for whole peanuts (Fig. 13) which, in turn, was less than that for hulls (Fig. 8) as expected. VF for kernels was relatively constant throughout the moisture range tending to decrease at the highest moisture con-

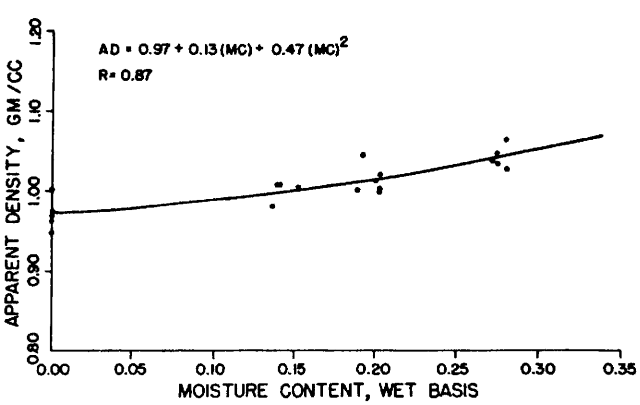

Fig. 1 Apparent density of kernels vs. moisture content.

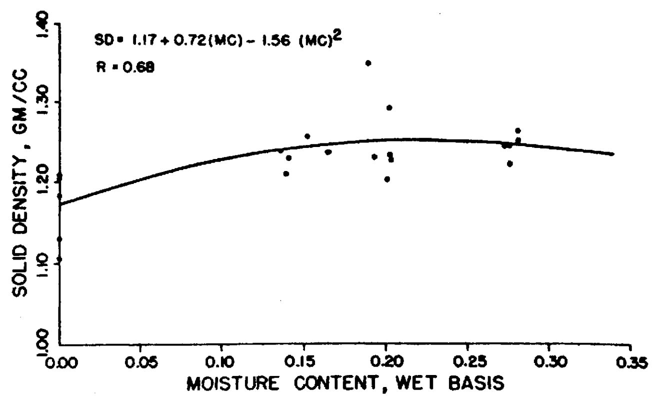

Fig. 2 Solid density of kernels vs. moisture content.

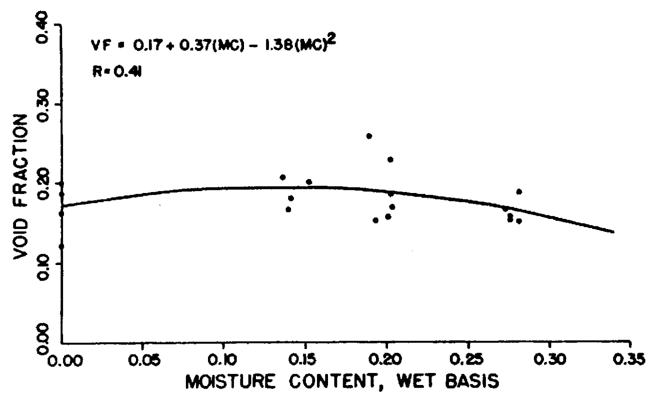

Fig. 3 Void fraction of kernels vs. moisture content.

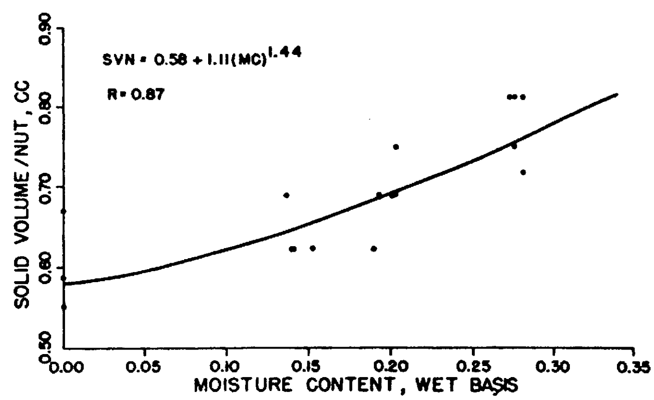

Fig. 4 Solid volume per nut for kernels vs. moisture content.

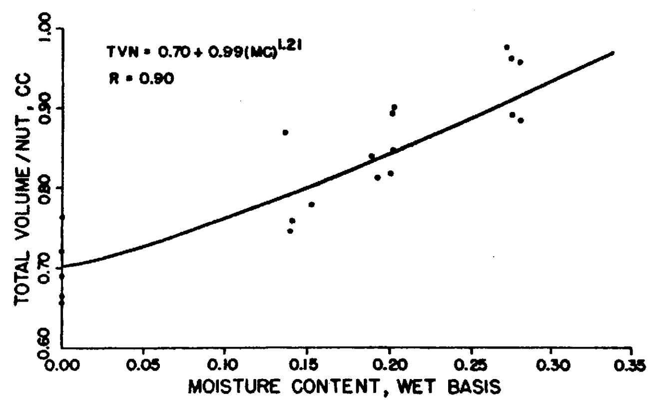

Fig. 5 Total volume per nut for kernels vs. moisture content.

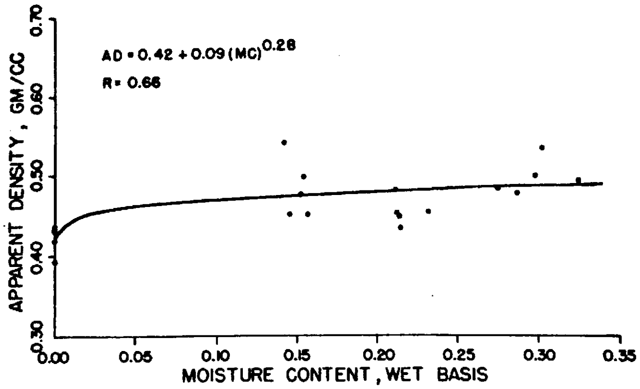

Fig. 6 Apparent density of hulls vs. moisture content.

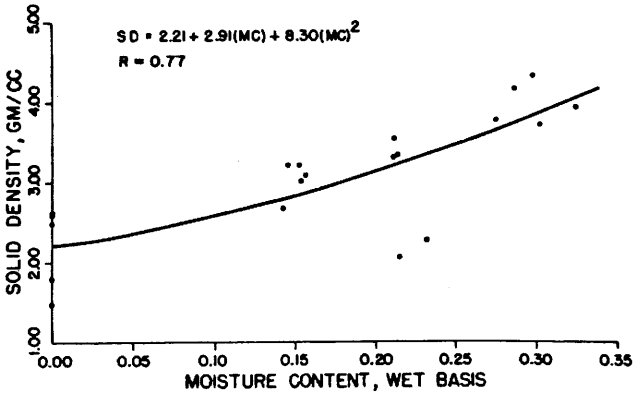

Fig. 7 Solid density of hulls vs. moisture content.

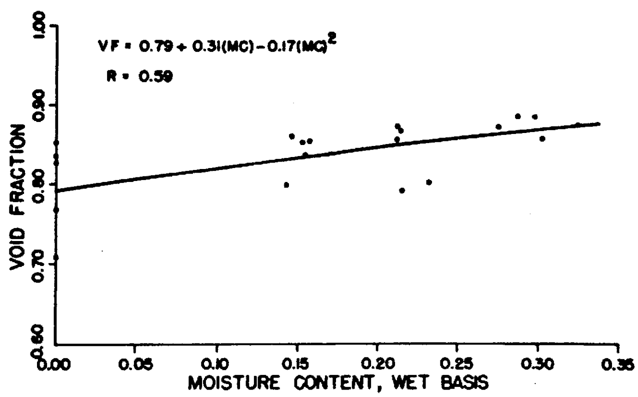

Fig. 8 Void fraction of hulls vs. moisture content.

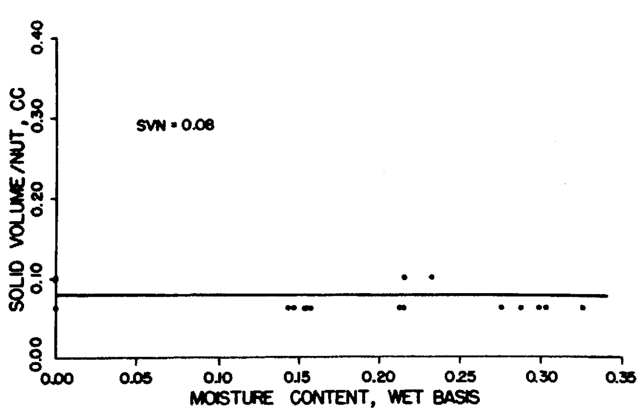

Fig. 9 Solid volume per nut for hulls vs. moisture conten.

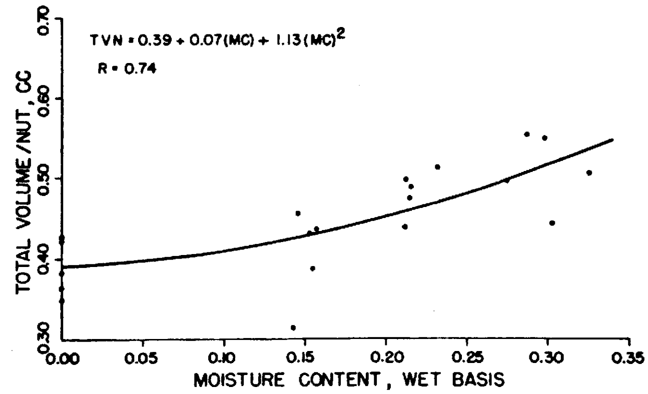

Fig. 10 Total volume per nut for hulls vs. moisture content.

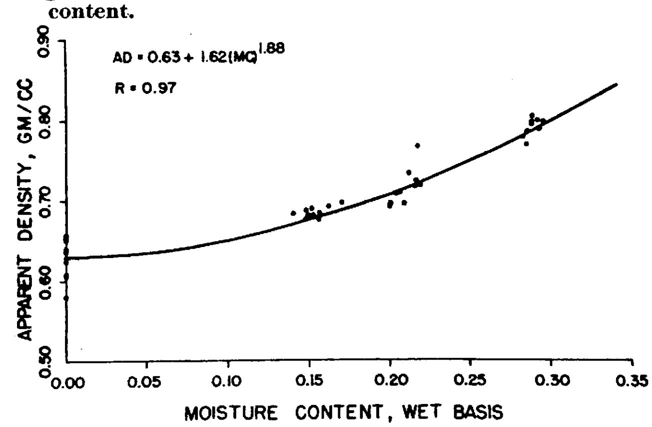

Fig. 11 Apparent density of whole peanuts vs. moisture content.

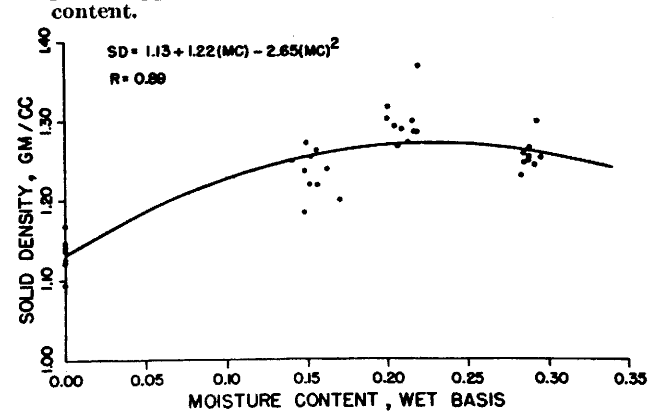

Fig. 12 Solid density of whole peanuts vs. moisture content.

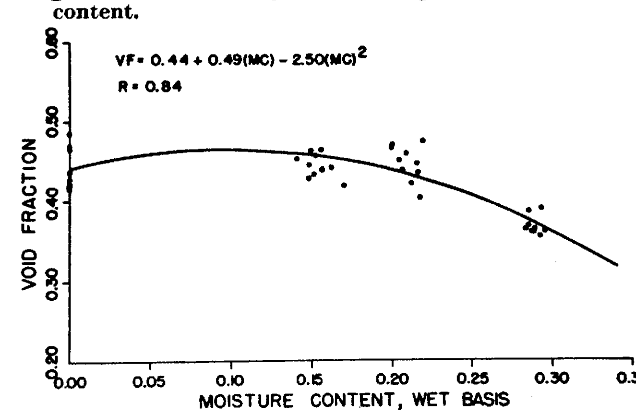

Fig. 13 Void fraction of whole peanuts vs. moisture content.

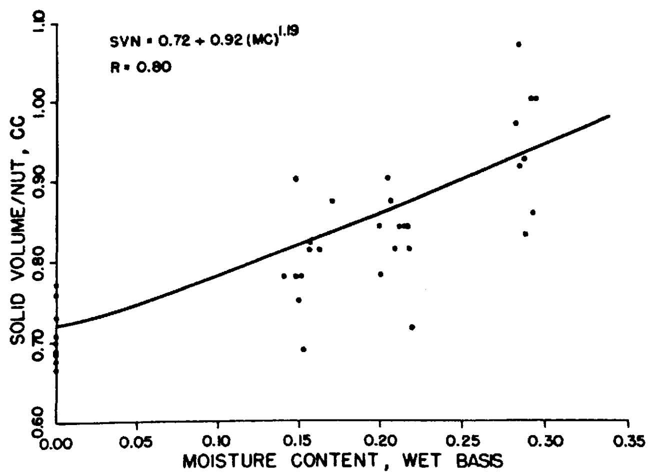

Fig. 14 Solid volume for whole peanuts vs. moisture content.

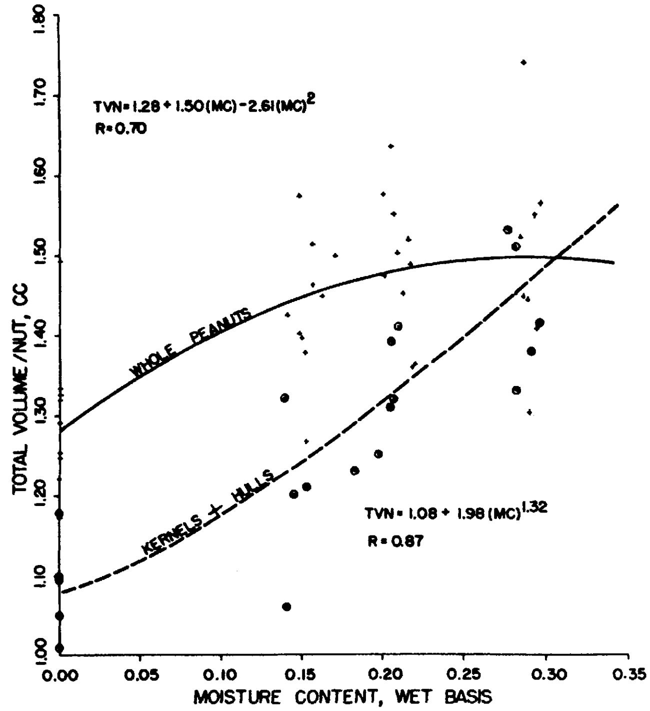

Fig. 15 Total volume for whole peanuts vs. moisture content. Upper curve (solid) represents intact peanuts. Lower curve (dashed) represents kernel volumes plus hull volumes taken separately.

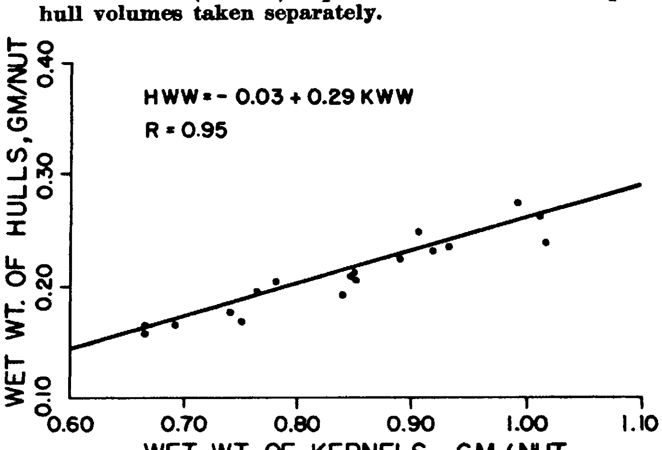

Fig. 16 Hull wet weight vs. kernel wet weight.

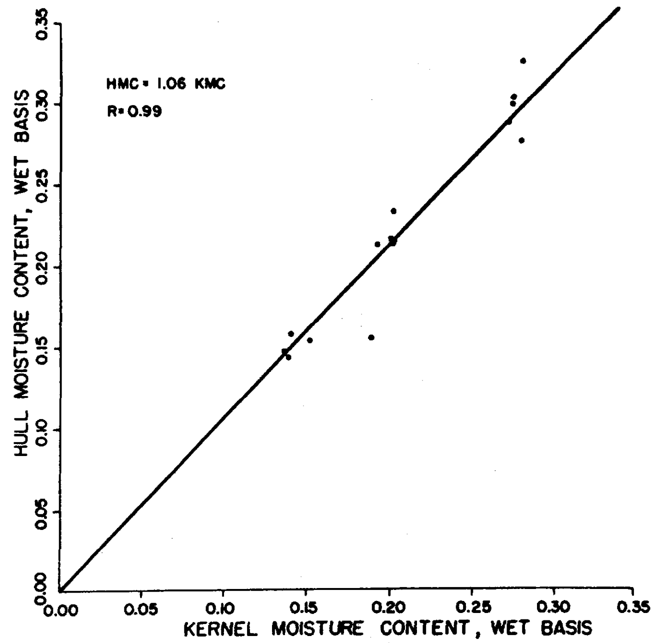

Fig. 17 Hull moisture content vs. kernel moisture content.

tents. Surprisingly, VF for hulls increased slightly with moisture content. VF for whole peanuts decreased rapidly at the higher moisture contents, probably due to the filling of the space between the kernels and hulls.

Strictly speaking the total volumes per nut (TVN) and solid volumes per nut (SVN) would apply only to the peanuts tested and could be expected to vary from lot to lot or from year to year. Although the peanuts used in these tests were from one year's harvest, these results can be expected to be typical, especially the relationships to moisture content. TVN for both kernels (Fig. 5) and hulls (Fig. 10) had a tendency to increase with moisture content. Figure 15 depicts two curves for TVN for whole peanuts. The upper (solid curve) was taken directly from measurements on intact peanuts. The lower curve was derived by adding the separate volumes of hulls and kernels from the same original samples and plotting this against their composite moisture contents. The space between the two curves theoretically represents the void space between the kernels and the hull of a peanut. The two curves cross at approximately 31% MC. Visual observations indicated that the hull cavities were completely filled only at the highest nominal moisture contents in the test. It appeared, in fact, that the swollen kernels tended to compress the soft inner layers of the hulls. This seems to explain why the TVN curves for hulls and kernels separately did not tend to level off at high moisture content as did the curve for whole peanuts.

SVN curves for kernels (Fig. 4) and whole peanuts (Fig. 14) tended to have the same shape as the TVN curves. SVN for hulls (Fig. 9) tended to be very small, approximately 0.08 cc/nut as an average value. Larger samples or more precise volumetric measurements would be necessary to obtain a more accurate relationship between this property and moisture content. Values ranged from 4.7 to 8.9 cc for samples, (hulls from 20 nuts in each sample), with no apparent trend respective to moisture content.

The solid density (SD) curves for kernels (Fig. 2) and whole peanuts (Fig. 12) had similar shapes, tending to rise to maximum values and then level off. The range of values in both cases was similar. SD for hulls (Fig. 7) continued to increase with moisture content and the values appear to be quite high.

Apparent density (AD) for hulls (Fig. 6) tended to increase initially from zero moisture content and then remain fairly constant. AD for kernels (Fig. 1) and whole peanuts (Fig. 11) tended to continue increasing with increasing moisture content, more rapidly, however, for whole peanuts. This again may be due to the effect of the kernels compressing the inner hull layers at high moisture contents.

Hull wet weight (HWW) is approximately 26% of kernel wet weight (KWW) (Fig. 16). Beasley and Dickens (1963) gave a typical range of 23% to 27% for Virginia type peanuts.

The hull moisture content (HMC) appears to be about 6% greater than the kernel moisture content (KMC) at any equilibrium moisture level (Fig. 17). This indicates that for typical forced convection, drying the hull could remove some moisture from the kernel after drying operations ceased. This also agrees with Beasley's and Dicken's findings for Virginia peanuts.

Selected Bibliography

Beasley, E. O. and J. W. Dickens, 1963. Engineering Research in Peanut Curing. N.C. Agr. Exp. Sta. Tech. Bull. No. 155, Raleigh, N. C.

Brusewitz, G. H. and L. J. Hamilton, 1972. Effect of Maturity on Heat of Respiration of Peanuts. ASAE Paper No. 72-837, ASAE, St. Joseph, Michigan 49085.

Dickens, J. W. and H. E. Pattee, 1972. Peanuts-Culture and Uses. Coyt T. Wilson, ed., American Peanut Research and Education Association, Inc., Stone Printing Co., Roanoke, Virginia. Chap. 15, pp. 509-522.

Nelson, G. L. and E. E. Gay, Jr., 1971. Spouted Bed Fluid and Transport Processes for Coarse Biological Materials. Transactions of the ASAE 14:527-530.

Suter, D. A., K. K. Agrawal, and B. L. Clary, 1972. Thermal Properties of Peanut Pods, Hulls and Kernels. ASAE Paper No. 72-377, ASAE, St. Joseph, Michigan 49085.

Suter, D. A. and B. L. Clary, 1973. Heat of Respiration of High Moisture Spanish Peanuts. Transactions of the ASAE 16:516-519.

Whitaker, T. B. and J. H. Young, 1972 a. Simulation of Moisture Movement in Peanut Kernels: Evaluation of the Diffusion Equation. Transactions of the ASAE 15:163-166.

Whitaker, T. B. and J. H. Young, 1972 b. Application of the Vapor-Diffusion Equation for Concentric Spheres in Describing Moisture Movement in Peanut Pods. Transactions of the ASAE 15:167-171, 174.

Whitney, J. D. and J. G. Porterfield, 1967. Dielectric Properties of Peanuts. Transactions of the ASAE 10:38-40.

Wright, M. E. and J. G. Porterfield, 1970. Specific Heat of Spanish Peanuts. Transactions of the ASAE 13:508-510.

Wright, M. E. and J. G. Porterfield, 1971. Heating and Drying Peanuts with Radio-Frequency Energy. Transactions of the ASAE 14:620-633, 637.

Young, J. H. and T. B. Whitaker, 1971. Evaluation of the Diffusion Equation for Describing Thin Layer Drying of Peanuts in the Hull. Transactions of the ASAE 14:309-312.