Hygroscopic Equilibrium of Peanuts

MELVIN L. KARON and BARBARA E. HILLERY, Southern Regional Research Laboratory,[1]
New Orleans 19, Louisiana

MOISTURE plays an important role in the curing and storage of peanuts. If the peanuts remain at a high moisture level too long after harvest, they may heat, sprout, or mildew. If they are dried too rapidly, the skins may become loosened and the kernels may become damaged. Consequently both the actual moisture content of peanuts at any stage of handling and storage and rate of change of moisture content during curing are of considerable importance.

An investigation of the hygroscopic equilibrium and rate of attainment of hygroscopic equilibrium of whole peanuts and the component shells, skins, kernels, and hearts has been carried out over the range of 11-93% relative humidity at a temperature of 25°C. Freshly dug, naturally cured, and artificially cured peanuts of both the Runner and Spanish type were investigated.

Materials and Methods

The procedure used to obtain the desired atmospheric relative humidity in contact with the peanuts and derived products was the same as that previously described (1). The salts used in the preparation of the required saturated solutions and their relative humidities (2) at 25°C. are shown in Table I.

TABLE I

Relative Humidity of Atmosphere in Contact with Saturated Solutions of Various Salts at 25°C.

Salt	Relative humidity
	%
1. Lithium chloride	11.1
2. Potassium acetate	22.5
3. Magnesium chloride hexahydrate	32.5
4. Potassium carbonate	43.7
5. Sodium dichromate dihydrate	53.3
6. Sodium nitrite	64.4
7. Sodium chloride	75.4
8. Potassium chromate	86.4
9. Ammonium dihydrogen phosphate	92.5

The peanuts used in this investigation comprised different lots of Spanish and Runner varieties obtained from commercial shellers in Georgia and Florida and the Agricultural Engineering Department of Alabama Polytechnic Institute. Each sample of peanuts was thoroughly cleaned of sticks, stems, broken kernels, stones, and other trash prior to analysis, the results of which are given in Table II.

Experimental

Duplicate portions of each sample of peanuts were weighed into wire baskets (2″ in diameter and 1½″ high) which were stored at 25°C. in humidifying chambers consisting of large desiccators containing wire mats suspended over mixtures of saturated salt solutions and excess salts. At regular intervals the baskets and contents were removed from the desiccator, placed in closed moisture dishes, and weighed on the analytical balance. When three successive weighings over a period of not less than a week indicated not more than 0.05% change in weight of the peanuts, they were considered to be at equilibrium and their moisture contents were determined.

The naturally cured peanuts (sample No. 263) were manually separated into shells and kernels and the latter were further separated into skins, meats, and hearts. The hygroscopic equilibrium of each component was determined in the same manner as that of the whole peanuts. The weight distribution of the components was 74.8% kernels and 25.2% shells on a as received basis. The weight distribution of the whole kernel was 94.44% meats, 3.02% skins, and 2.54% hearts.

TABLE II

Analysis of Peanuts Used in Hygroscopic Equilibrium Determinations

Sample No.	Shells %	Sound kernels %	Original moisture %	Lipids %	Nitrogen %	F.F.A. %	Wt. of 100 kernels
227	20.6	95.5	6.91	44.36	4.85	0.28	32.2 g.
228	21.1	97.5	5.96	45.58	4.67	0.99	32.7 g.
261	26.8	95.0	6.80	44.62	4.97	0.72	37.0 g.
262	24.9	98.5	6.63	44.98	4.87	0.38	39.0 g.
263	24.8	99.7	6.21	44.82	4.95	0.37	39.2 g.
280	30.8	98.4	29.93	34.42	3.50	0.67	41.1 g.

227—Spanish farmers' stock peanuts well cured.
228—Spanish peanuts from Moultrie, Georgia.
261—Runner peanuts naturally dried to 31.8% moisture; artificially dried to 7.7% moisture.
262—Runner peanuts naturally dried to 21.5% moisture; artificially dried to 7.4% moisture.
263—Runner peanuts naturally cured.
280—Freshly dug Spanish peanuts.

An investigation of the method for the determination of moisture in peanuts by Hoffpauir (3) indicated that the optimum conditions for the drying of peanut kernels were heating at 130°C. in a forced-draft oven for a period of five hours. Most of the work reported in this investigation was on unshelled peanuts, which behave differently on drying than do shelled peanuts. It was therefore necessary to devise a method for determining moisture in unshelled peanuts which would be analogous to that applicable for shelled peanuts.

In an effort to develop an applicable method large samples of peanuts were divided into three portions, one of which was unshelled, another had the shells cracked but not removed, and the third was quantitatively separated into shells and kernels. Each sample was then dried at 130° in a forced-draft oven. It was assumed that cracking the shells would expose the kernels to the same external environment as were the kernels investigated by Hoffpauir (3). If, therefore, drying occurred to the same extent in five hours, as in the case of shelled kernels Hoffpauir's method could be applied without modification. Actually the results obtained on unshelled peanuts and peanuts with cracked shells indicated that after 6 hours at 130°C. in the forced-draft oven the former attained the same moisture content as the latter did in 5 hours under the same conditions. Therefore all moisture determinations reported in this investigation on peanuts were made by drying the material for 6 hours at 130°C. in a forced-draft oven and are reported on a wet basis.

[1] One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, United States Department of Agriculture.

Results

The effect of the length of storage under conditions of constant relative humidity at 25°C. on the moisture content of freshly dug and naturally cured peanuts is shown in Figures 1 and 2, respectively. In the case of the naturally cured peanuts it can be seen that the rate of sorption or desorption of water depends on the difference between the actual moisture content of the peanut and the moisture content

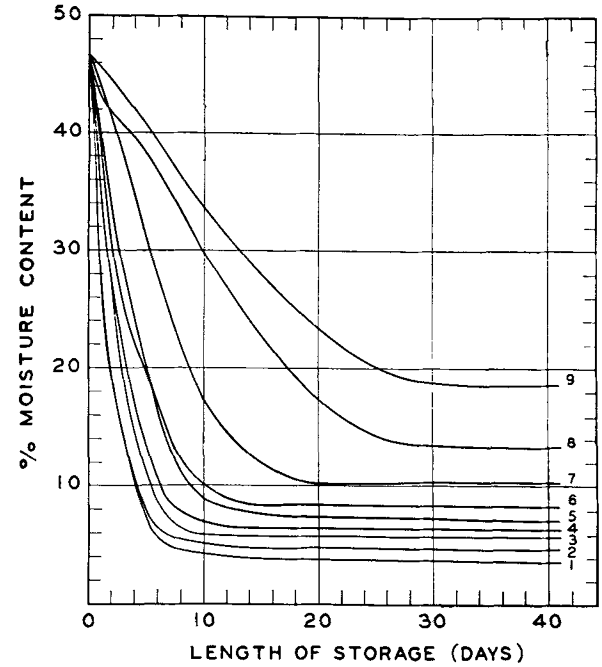

FIG. 1. Effect of length of storage at constant relative humidity on the moisture content of freshly dug whole Spanish peanuts. Numbers refer to relative humidities given in Table 1.

at which equilibrium is finally attained for any given relative humidity. All samples attained equilibrium within 10 days. In the case of freshly dug peanuts the rate of attainment of hygroscopic equilibrium was found to depend almost entirely on the relative humidity of the air surrounding the sample. Although samples which were maintained at low relative humidity attained equilibrium in about 10 days, those kept at 92.5% or 86.4% relative humidity required approximately 30 days to attain equilibrium. The final equilibrium moisture contents of the naturally dried peanuts obtained from the data in Figure 2 are plotted as a function of relative humidity in

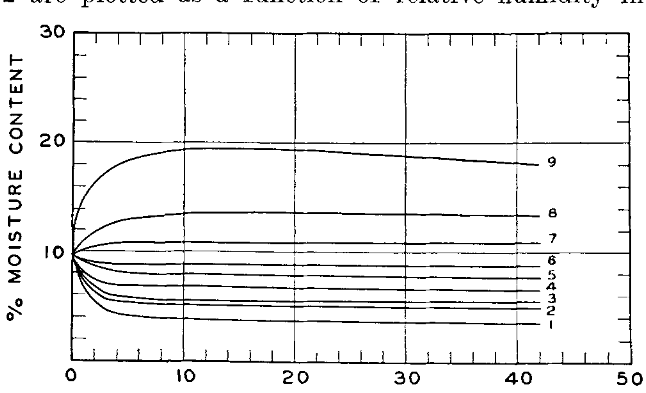

FIG. 2. Effect of length of storage at constant relative humidity on the moisture content of naturally cured whole Runner peanuts. Numbers refer to relative humidities given in Table 1.

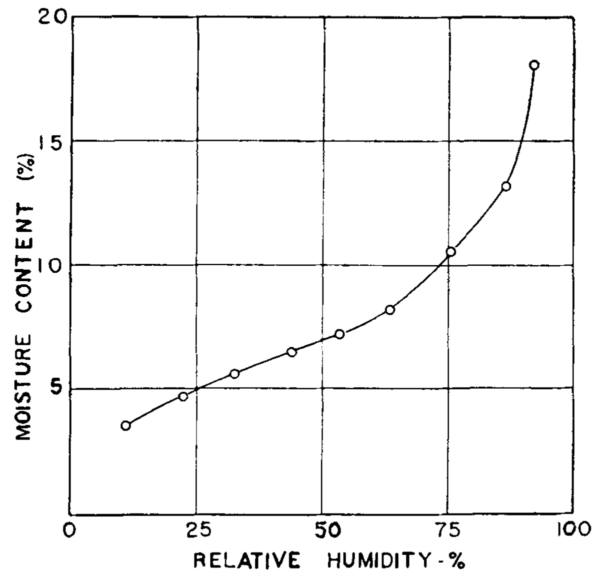

FIG. 3. Hygroscopic equilibrium of naturally cured whole Runner peanuts.

Figure 3. Similar curves to that of Figure 3 were obtained with freshly dug peanuts and all other samples investigated. The data for the hygroscopic equilibrium of the components of peanut kernels (meats, hearts, and skins) are given in Figure 4.

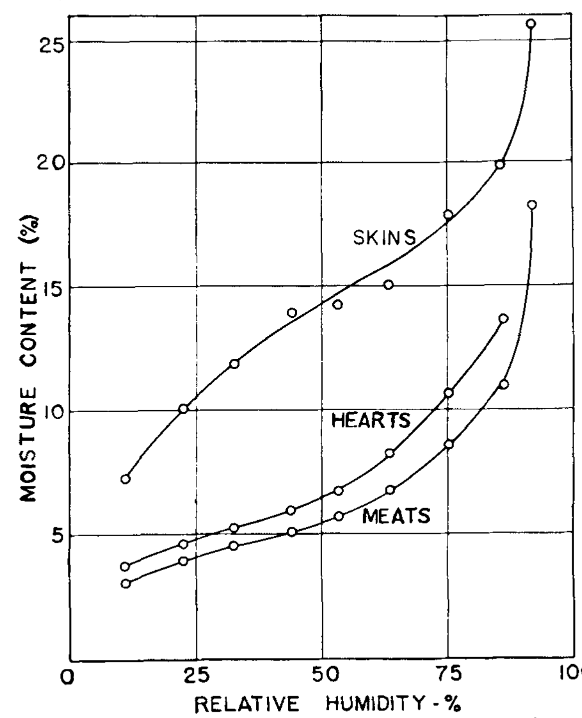

FIG. 4. Hygroscopic equilibrium of components of the kernels of naturally cured Runner peanuts.

A sample of naturally cured Runner peanuts was divided into two equal portions, one of which was further dried under vacuum at room temperature to a moisture content of 1.5%. Moisture was added to the other portion by exposing it to an atmosphere of 100% relative humidity at 3-5°C. until a moisture content of 14.5% was attained. Duplicate samples of each portion were placed in each conditioning chamber and the moisture content determined when equilibrium was attained. The difference in moisture content between the two samples at any constant relative humidity provides a measure of the hysteresis loop resulting from successive drying and rewetting. The results of this experiment and the hygroscopic equilibrium of peanut shells and kernels are shown in Figure 5. All of the results on hygroscopic equilibrium are given in Table III.

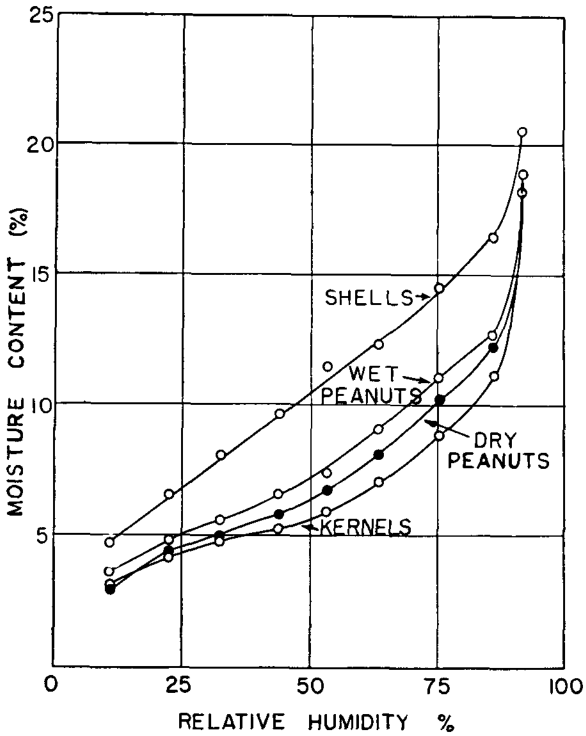

FIG. 5. Hygroscopic equilibrium of whole peanuts, shells, and kernels of naturally cured Runner peanuts.

The hygroscopic equilibrium curve for whole peanuts is similar to that of cottonseed (4). All samples investigated, regardless of whether they were of Runner or Spanish type or of the manner in which they were dried, exhibited very similar results. In the whole peanut, the shells contained more moisture than the kernels, however, the kernels contained a large percentage of oil which is responsible for some of the observed differences in moisture content. In the peanut kernel the skins contained the greatest percentage of moisture at constant relative humidity but in this case the presence of oil cannot account for the observed difference.

The data in Table 3 indicate that variety and method of curing do not play an important role in the moisture content of peanuts maintained at any given relative humidity. Rewetting the peanut after it has been dried affects the moisture content in equilibrium with any given constant relative humidity. In the whole peanut at a constant relative humidity the maximum moisture content was found in the skins, and, in order of decreasing moisture content, in the shells, hearts, and meats, respectively.

In order to determine whether the moisture content of peanuts is a function of the relative or absolute humidity an investigation was made of the rate of attainment of hygroscopic equilibrium of freshly dug, naturally cured, and artificially cured peanuts at approximately 22, 53, and 86% relative humidity and at temperatures of 25 and 35°C. In these experiments the air over the peanuts was circulated by means of syncronous motor driven paddles. The results for naturally dried peanuts are shown in Figure 6.

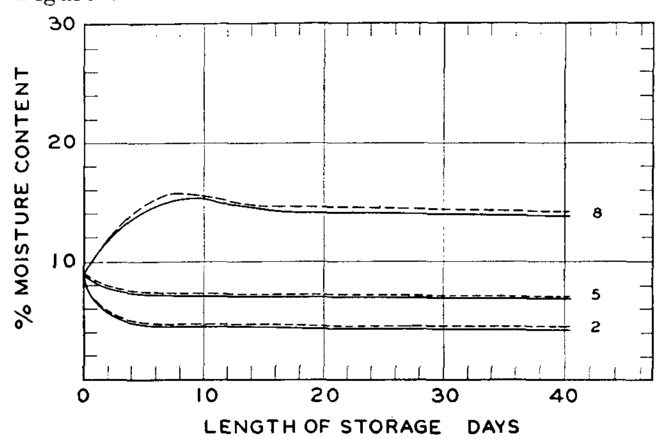

FIG. 6. Effect of length of storage on constant relative humidity and temperature on the moisture content of naturally cured Runner peanuts.

	No. 2	No. 5	No. 8
---25°C.	22.5% R.H.	53.3% R.H.	86.4% R.H.
—— 35°C.	21 % R.H.	50.7% R.H.	85.8% R.H.

The same results were obtained for artificially cured peanuts. The experimental results for the freshly dug peanuts are shown in Figure 7. It can be seen from Figure 7 that at high humidities, the peanuts at 35°C. dry more rapidly. A comparison of Figures 2 and 7 indicates an acceleration in drying which can be effected by the use of circulating air. In these figures it is observed that the equilib-

TABLE III

Percentage of Equilibrium Moisture of Whole Peanuts and Components Maintained at Constant Relative Humidity

Sample No. and Product	Equilibrium moisture content — Relative humidity of conditioning atmosphere — Moisture Content (Wet Basis)								
	11.1%	22.5%	32.5%	43.7%	53.3%	64.4%	75.4%	86.4%	92.5%
227	3.60	4.47	5.53	6.30	7.22	8.02	10.12	12.87	21.0
228	3.65	4.68	5.45	6.35	7.17	8.34	10.27	13.15	21.5
261	3.64	4.64	5.63	6.47	7.34	8.24	10.23	14.24	19.0
262	3.55	4.66	5.47	6.33	7.28	8.46	10.54	13.57	19.6
263	3.49	4.85	5.59	6.53	7.72	8.78	10.91	13.70	19.4
280	3.51	4.61	5.57	6.32	7.14	8.20	10.42	13.21	18.2
263—Dried	2.93	4.38	4.96	5.81	6.86	8.11	10.27	12.26	19.0
263—Wet	3.61	4.80	5.88	6.60	7.40	9.07	11.08	12.75	19.3
263—Shells	4.73	6.58	8.10	9.64	11.48	12.36	14.53	16.49	20.6
263—Kernels	3.19	4.15	4.75	5.24	5.91	7.04	8.85	11.14	17.2
263—Meats	3.08	3.94	4.50	5.11	5.74	6.81	8.64	11.68	18.6
263—Hearts	3.72	4.60	5.26	5.98	6.76	8.25	10.70	17.20	25.9
263—Skins	7.24	11.15	11.89	13.90	14.29	15.05	17.85	19.91	25.8

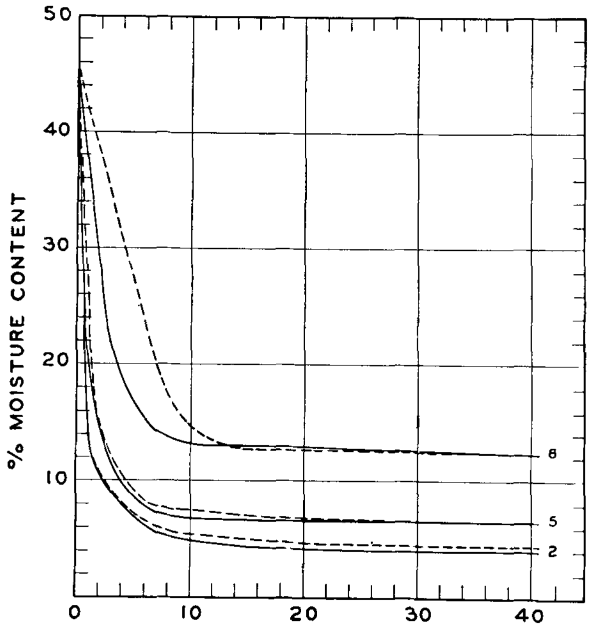

FIG. 7. Effect of length of storage at constant relative humidity and temperature on the moisture content of freshly dug Spanish peanuts.

	No. 2	No. 5	No. 8
---25°C.	22.5% R.H.	53.3% R.H.	86.4% R.H.
——35°C.	21 % R.H.	50.7% R.H.	85.8% R.H.

rium moisture content at 35° is lower than that at 25°. The slight differences are probably the result of the slightly lower relative humidity at 35°C.

Summary and Conclusions

The hygroscopic equilibria and rates of attainment of hygroscopic equilibrium of freshly dug, naturally cured, and artificially cured peanuts have been determined over the range of 11-93% relative humidity at 25°C. The hygroscopic equilibrium does not appear to be dependent on the method of curing. At a constant relative humidity, the moisture content is distributed so that the moisture content of the skins is twice that of the meats and in general the moisture content is lowest in the meats, and is increasingly greater in hearts, shells, and skins, respectively.

At 25° and 35°C. the relative humidity is of greater importance than the absolute humidity. Circulation of the air over the samples greatly increases the rate of attainment of hygroscopic equilibrium. At the higher temperature, the rate of attainment of hygroscopic equilibrium is further increased because of the increased rate of diffusion of moisture in the seed.

Inasmuch as the hygroscopic equilibrium is the same at both 25° and 35°C., it is more advantageous when speed of drying is important to use the higher temperature because equilibrium is attained more rapidly.

REFERENCES

1. Karon, M. L., J. Am. Oil Chem. Soc., *24*, 56-58 (1947).

2. American Paper and Pulp Association, Report No. 40, Instrumentation Program, February 15, 1945.

3. Hoffpauir, C. L., Oil and Soap, *22*, 283-286 (1945).

4. Karon, M. L., and Adams, M. E., J. Am. Oil Chem. Soc., *25*, 21-22 (1948).

Gossypol and Gossypurpurin in Cottonseed of Different Varieties of G. barbadense and G. hirsutum, and Variation of the Pigments During Storage of the Seed*

CHARLOTTE H. BOATNER, LEAH E. CASTILLON, C. M. HALL, Southern Regional Research Laboratory,[1] New Orleans, Louisiana, and J. WINSTON NEELY, U. S. Cotton Field Station and Delta Experiment Station,[2] Stoneville, Mississippi

Summary

Selected varieties of cottonseed comprising three Sea Island cottons, four Egyptian cottons, and 10 upland cottons providing two or more varieties having the following characteristics: short, intermediate, and long staple; low, intermediate, and high content of lipids; and low, intermediate, and high content of protein, were planted and grown under as nearly identical conditions as possible.

The initial contents of moisture, lipids, nitrogen, gossypol, and gossypurpurin of the harvested seed were determined, after which samples of all of the seed were stored for a year under identical conditions and analyzed periodically for gossypol and gossypurpurin.

A definite relation was found between the species of the seed and their content of gossypol and gossypurpurin. Sea Island and Egyptian seed of the species *G. barbadense* contained more gossypol and very much more gossypurpurin than seed of the species *G. hirsutum*. Within the species *G. barbadense* Sea Island seed contained more gossypol and less gossypurpurin than Egyptian seed.

Gossypurpurin increased during storage of all of the seed whereas gossypol varied in a number of different ways, increasing in some, decreasing in others, and remaining relatively constant in a few samples of stored seed.

A discussion is presented of the theoretical and practical implications of these observations.

Introduction

BECAUSE of the economic importance of cotton and cottonseed, the effect of genetic and environmental factors on the properties of the lint and the composition of the seed has been the subject of extensive investigations (28) although relatively few have dealt with the content of pigments in cottonseed from different varieties of cotton grown in different

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[1] One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture.

[2] Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture.