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Peanut Quality Changes Associated with Deficient Warehouse Storage

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ABSTRACT

Studies on peanuts from five deficient warehouses revealed that excess moisture, high temperature, and mechanical damage resulted in peanut quality deterioration as evidenced by low grade factors, increased free fatty acids, and increased carbonyl content. Levels of deterioration were related to kernel condition and length of storage. Loose shelled kernels were highly susceptible to deterioration. The research emphasizes the need for reduced mechanical damage, improved ventilation, elimination of moisture concentrations, and minimizing length of storage of peanuts of marginal initial quality.

Key Words: Peanuts, Storage, Warehouse, Official Grade, Carbonyls, Free Fatty Acids.

Storage of farmers stock peanuts in the relatively uncontrolled environment of 3000- to 5000-tonne warehouses is critical in the continuing effort to maintain peanut quality from harvest to consumption. The limited number of studies belie the importance of research on warehouse conditions and the impact of those conditions on peanut quality. In the only study we found in which actual warehouse conditions were utilized, Brown and Steele (5) reported no significant deterioration in grade factors of peanut samples stored for 72 days in various locations of a warehouse. Simulated warehouse studies in steel containers and wooden cribs (5,13,14,16,21) provided indications of the changes that occur in conventional warehouse storage, but applications are limited because of great differences in condensation, leaks, insecticide application, handling, ventilation, and other such factors. Based on observation and unpublished data, Dickens and Hutchison (7) recommended practices for maintenance of quality in warehouse storage, but to our knowledge the study reported here is the first published information on quality deterioration of peanuts stored in conventional type warehouses. The study was conducted to provide a limited estimate of the potential for quality deterioration in commercial farmers stock peanut warehouses. Common, inferior storage environments were selected to provide the greatest opportunity to observe changes in peanut quality and to assess the need for continued research in this area.

Materials and Methods

Five warehouses for segregation I peanuts in southwest Georgia were identified as having various obviously deficient storage conditions. Some were identified during loading operations, while others were not identified until approximately one month later. Generally, samples were extracted from one location in the warehouse; however, to evaluate ventilation efficiency, one warehouse (B) was sampled 6, 12, and 15 meters from the fan. At each sample location, 40 kg of peanuts were removed and divided into 20-kg samples on a farmers stock peanut divider. The 20-kg samples were placed in mesh sample bags. One sample was returned to the laboratory and analyzed; the other sample was placed in the original location in the warehouse, covered with 30 cm of peanuts, and analyzed when storage was terminated. Samples were divided on a farmers stock peanut divider to obtain duplicate 1000 g samples for official grade determinations (19). Sound mature kernels plus sound splits (SMK + SS), loose shelled kernels (LSK), other kernels (OK), and damaged kernels (DK) from the grade samples were ground in a hammer mill or Waring Blendor and duplicate 4-g samples were immediately extracted with toluene as the initial step of the carbonyl assay. Total carbonyls were determined by a modification of the 2,4-dinitrophenyl hydrazine method of Henick et al. (10). Duplicate free fatty acid determinations were made on oil from the ground samples according to AOCS Methods Aa 6-38 (1).

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Results and Discussion

Warehouse deficiencies were generally of two related types - moisture and ventilation (Table 1). Moisture accumulations resulted from physical deficiencies such as leaks, defective or improperly operated drag-belt insecticide spray systems, and condensation. Condensation is possibly the greatest problem and results mainly from inadequate ventilation. Most warehouses are equipped with large fans in one end that draw air over the peanut pile through louvers in the other end. If these fans are not operated properly, warm moist air remains in the warehouse, condenses on the cool roof surfaces, and drips consistently on specific areas of the peanut pile. During the warm, early months of storage, the problem is the greatest and may result in several hundred gallons of water dripping from roof structures along localized drip lines. This results in concentrated areas of moldy, low quality peanuts which are dispersed during warehouse unloading.

Table 1. Storage deficiencies of five selected peanut warehouses

	WAREHOUSE				
DEFICIENCY	A	B	C	D	E
Condensation		X	X	X	
Spray Problem			X		X
Leaks				X	
Ventilation	X	X	X	X	X
Partitions				X	X
Sampling Date					
Initial	10/3	11/6	9/27	9/27	9/19
Final	12/11	12/7	3/1	3/4	12/12

Since the initial samples were taken at the time the problems were identified, peanuts had already been subjected to deficient storage for varying lengths of time. Few peanuts were loaded into the warehouses after late September; therefore, depending on the specific warehouse, samples may have been subjected to poor storage from less than one week or up to two months before the initial sample was taken. In most cases, corrective procedures were initiated, but the data demonstrate that quality deterioration had already begun.

Official grade data provided the first indications of quality deterioration under the deficient storage conditions (Table 2). Although the grade in some warehouse locations changed very little, as reported by Brown and Steele (5), the percentages of SMK + SS, OK, DK, and hulls were consistently related.

Table 2. Initial (I) and Final (F) official grade of peanuts from deficient warehouses

WHSE	SMK + SS		DAMAGE		HULL		OK	
	Percent Weight							
	I	F	I	F	I	F	I	F
A	74.3	74.9	1.2	1.4	21.0	20.5	3.5	3.2
B_6*	69.0	70.8	3.0	2.1	23.7	23.5	4.3	3.6
B_{12}	70.5	70.4	2.5	2.5	23.4	23.0	3.6	4.1
B_{15}	75.4	72.5	2.9	2.2	19.2	22.6	2.4	2.6
C	74.0	68.1	2.1	6.3	20.5	22.9	3.3	2.9
D	72.8	69.8	1.9	5.5	20.9	21.5	3.6	3.7
E	65.9	69.3	4.6	2.5	23.4	23.3	5.9	5.1

* In Warehouse B, samples were taken 6, 12, and 15 meters from the ventilation fan.
All data are the mean of duplicate analyses.

The most notable deteriorations in grade were found in warehouses B_{15}, C, and D where SMK + SS decreased 2.9, 5.9, and 3.0%, respectively. The decreases in C and D were related to an increase in the percentage DK. Johnson and Gilliland (13) found similar relationships in simulated warehouse storage and reported that occurrences of this type were generally related to long-term storage (6 mo). Peanuts in warehouses C and D were stored approximately 6 mo, and this length of time seems to have been sufficient for substantial visible damage to occur. In warehouse B_{15}, the decrease in SMK + SS was related only to an increase in percent hulls, since DK also decreased in the final sample. There was little change in grade of peanuts in warehouses A and B_{15}; however, in B_6 and E, SMK + SS increased 1.8 and 3.4%, respectively. These increases were associated with decreases in both percent DK and OK. Although data presented later indicate that quality deterioration had begun, visible evidence was lacking in warehouses A, B_6, B_{12}, and E. Early unloading of these warehouses probably contributed substantially to the lack of increased visible damage of the peanuts. The relationship between deficient warehouse storage conditions, long-term storage, decreased SMK + SS, and increased damage is consistent. Although further research is needed, the data suggest that early warehouse unloading and processing after poor storage conditions are detected may be one way to diminish losses.

Percent moisture and segregation data are presented in Table 3. Warehouses C, D, and E initially contained peanuts which were too moist for safe storage. The mean percentages of 9.2-9.9 indicate that a large number of peanuts contained over 10% moisture. Moisture percentages of 9-10% in SMK are considered only marginally safe from *Aspergillus flavus* growth in storage (8,9). These percentages, when combined with high temperatures generated in the pile of peanuts (17,18), provided even less safe storage conditions. Peanuts in warehouses C, D, and E were graded segregation III (presence of visible *A. flavus*) in the initial and final samples after being loaded into warehouses as segregation I peanuts. Therefore, they were either graded incorrectly due to sampling error or conditions were adequate for proliferation of existing *A. flavus* mycelium and/or spores. It is noteworthy that the final moisture contents in warehouses C, D, and E had decreased substantially and suggests that much of the fungus growth must have occurred early in the storage period while moisture content was still high. This data is in general agreement with the overall increase in the percent DK found in grade samples from warehouses C and D, but appears contradictory to the decrease in DK in warehouse E after about 3 mo storage.

Table 3. Initial (I) and Final (F) moisture content and segregation category of peanuts from deficient warehouse storage

WHSE	% MOISTURE		SEGREGATION
	I	F	I & F
A	6.8	6.4	1
B_6*	7.3	6.7	1
B_{12}	7.0	7.0	1
B_{15}	7.0	7.0	3
C	9.2	5.5	3
D	9.9	5.7	3
E	9.9	6.6	3

* In Warehouse B, samples were taken 6, 12, and 15 meters from the ventilation fan.

All data are the mean of duplicate analyses.

Percent free fatty acid (FFA) of the oil from various grade samples in Table 4 provides an indication of hydrolytic rancidity which may result from mold invasion of the peanuts (8). The normal range of FFA values for peanuts is 0.02-0.6% (6); however, values on the lower end of the range may be preferred as an indication of good quality. FFA percentages of all the initial SMK + SS samples were in the reported normal range for peanuts; however, the higher values found in warehouses B_{15}, D, and E probably indicate that quality deterioration had occurred. *A. flavus* is one of many fungi that cause large increases in FFA in peanuts (8, 20) and the fact that peanuts from these three warehouses contained visible *A. flavus* (segregation III, Table 3) in the initial sample may be related to the higher FFA values observed in SMK + SS, LSK, and DK. In any case, visible growth of *A. flavus* does indicate that conditions were very favorable for mold growth during early storage in those warehouses. In the final SMK + SS samples, FFA percentages were highest in peanuts that had been stored for the longest periods of time.

In warehouses A, B_6, B_{15}, and C, the inital OK samples contained higher FFA percentages than the initial SMK + SS samples. This is probably not due to greater mold invasion but to the difference in maturity level. Sanders (15) previously demonstrated that FFA percentages decreased as peanuts matured; therefore, SMK + SS, comprised of larger and more mature seed, should contain less FFA than OK, comprised of small, immature seed. FFA increases in OK were similar to those found for SMK + SS in the respective warehouses.

Table 4. Free fatty acid content of Initial (I) and Final (F) grade samples from deficient warehouses

WHSE	SMK + SS		OK		LSK		DAMAGED	
	Percent as Oleic Acid							
	I	F	I	F	I	F	I	F
A	0.11	0.15	0.28	0.25	-	-	-	1.3
B_6*	0.13	0.20	0.30	0.30	0.35	1.00	0.72	2.10
B_{12}	0.13	0.18	0.30	0.30	0.20	0.45	1.50	0.90
B_{15}	0.63	0.65	0.45	0.53	6.28	6.70	29.45	26.00
C	0.12	1.05	0.20	1.2	1.95	13.0	3.88	6.45
D	0.38	1.18	0.28	1.8	3.05	12.3	3.89	19.60
E	0.60	1.12	-	-	4.75	5.8	4.44	4.80

* In Warehouse B, samples were taken 6, 12, and 15 meters from the ventilation fan.

All data are the mean of duplicate analyses.

LSK contained very high FFA percentages which indicate that they had been heavily invaded by mold. In each warehouse where peanuts were graded segregation III, the visible *A. flavus* was found in the LSK's. Blankenship et al. (2) examined 28 warehouse samples and found that LSK's had the highest occurrence of aflatoxin at 20 ppb or greater. In warehouse B_{15}, the storage time between initial and final samples was only one month and the increase in FFA was slight. The FFA increase in peanuts from warehouse E, storage time 3 mo, was higher than that in B_{15}; however, in warehouses C and D where extended storage took place, the increases in percent FFA in LSK were very large. The data on LSK from all warehouses indicate that they were highly susceptible to quality deterioration and places added emphasis on research directed at removal of LSK and foreign material before storage (3).

DK is a diverse separation that contains mold- and insect-damaged kernels as well as discolored kernels. This tends to confuse conclusions regarding the FFA data somewhat in that some good kernels that may be only slightly off-color are combined with some heavily damaged kernels. However, the data are sufficient to indicate the extreme quality deterioration resulting from mold and insect invasion.

Total carbonyl content of peanuts has been used as an index of rancidity and correlates well with taste panel evaluations (10,11,12). Brown et al. (4) reported 0.62 m mole carbonyl/kg of raw, cold-pressed oil from No. 1 grade, Runner peanuts. This value is lower than the total carbonyl values reported in Table 5; however, the peanuts used by Brown et al. (4) had been maintained in cold storage since harvest. Total carbonyls of the SMK + SS increased only slightly or decreased except in the longer storage times of warehouses C and D. The initial values for C and D are low in comparison to others; however, this trend is generally consistent throughout the other samples, possibly because the peanuts had been in storage only a short time before initial sampling. The initial total carbonyl values of OK were slightly higher than SMK + SS; however, the increases with storage times were similar. The effect of maturity on carbonyl content of peanuts is not known, but the SMK + SS and OK data suggest that the concentration, like FFA (15), decreases with maturity. Research is in progress in our laboratory to determine carbonyl contents of various peanut maturity stages. The increase in total carbonyl was generally greater in LSK and damaged kernels than in SMK + SS and OK. Again, the susceptibility of LSK to quality deterioration is evident. Initial carbonyl values and the FFA data for SMK + SS and LSK in warehouses C and D provide comparisons of the rate of deterioration of LSK and kernels protected by the hull.

Table 5. Total carbonyls in Initial (I) and Final (F) grade samples from deficient warehouses

WHSE	SMK + SS		OK		LSK		DAMAGED	
	m moles carbonyl/kg oil							
	I	F	I	F	I	F	I	F
A	1.10	1.07	1.46	1.42	1.61	-	1.29	1.88
B_6*	1.33	1.32	2.00	2.19	1.35	1.80	1.37	3.30
B_{12}	1.10	1.38	2.26	2.28	1.24	1.75	2.84	3.94
B_{15}	1.26	1.45	1.93	2.13	1.87	2.23	3.12	4.07
C	0.74	1.56	1.33	2.82	1.15	2.17	1.46	2.27
D	0.81	1.17	1.44	1.60	1.32	2.01	1.62	2.63
E	1.55	1.26	-	1.76	1.96	1.93	2.04	2.57

* In Warehouse B, samples were taken 6, 12, and 15 meters from the ventilation fan.

All data are the mean of duplicate analyses.

Conclusions

The data obtained in this study indicate the need for improved warehousing of farmers stock peanuts to prevent excess moisture and temperature buildup during storage. Quality deterioration of LSK, as evidenced by increased FFA and total carbonyl content, as well as, increased occurrence of visible *Aspergillus flavus,* indicates the need for additional research directed at the removal of LSK and foreign material before storage. Data obtained in this study demonstrate that quality of farmers stock peanuts decreases as storage time increases when poor storage conditions exist and suggests that processing of peanuts as soon as possible after poor conditions are noted may be one way to diminish losses. This study graphically demonstrates the need for extensive investigation of environmental conditions that exist in conventional farmers stock peanut warehouses, interrelation of those conditions with peanut quality, and methods to assure quality maintenance.

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