Storability of Farmers Stock Peanuts at Two Moisture Levels in Mechanically and Naturally Ventilated Miniature Warehouses

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ABSTRACT

Farmers stock peanuts from the same field dried to either 8 or 10% seed moisture content were stored for 6 months (October through March) in mechanically and naturally ventilated miniature metal warehouses. The initial temperatures for the 8% moisture content peanuts were 2-3 C higher than those for the 10% moisture content peanuts. This differential was maintained until early February. Relative humidities, 10 percentage points higher in the 10% initial moisture content peanuts began to equilibrate in December and were similar by late January. Final moisture content of the peanuts from the two mechanically ventilated warehouses was about 7% compared to 7.5% in the two naturally ventilated warehouses. Only small changes in total carbonyls and free fatty acids occurred during storage in the warehouses and sensory evaluation after storage indicated no significant differences among treatments within the medium and No. 1 sizes. No aflatoxin was detected in any seed size category before or after storage. Results indicated that quality of farmers stock peanuts, initial moisture content at 10% or less, can be maintained when stored in a properly constructed and operated mechanically or naturally ventilated warehouse.

Key Words: *Arachis hypogaea,* L., warehouse, storage, moisture content, ventilation.

Quality is greatly affected by the moisture content of the peanuts and the environmental conditions during storage (10,11,14,15). High initial moisture content, unless reduced quickly, may create severe problems during storage and result in substantial losses in the value of the peanuts. Presently, farmers stock peanuts intended for the edible market cannot legally be bought and stored if the initial average moisture content (m.c.), wet basis, exceeds 10% (9).

The objectives of this research were to evaluate temperature, relative humidity, and quality changes that occurred in farmers stock peanuts stored at 8 and 10% m.c. in naturally and mechanically ventilated warehouses.

Materials and Methods

Farmers stock peanuts harvested from a 50-hectare field at an initial average seed m.c. of 17.5% were used in this study. Four loads of peanuts were used, each ca. 4080 kg. Peanuts were dried at a commercial drying facility, two loads to ca. 8% m.c. (8.5%) and two loads to ca. 10% m.c. (10 and 10.4%) referred to hereafter as initial 8 and 10% m.c. peanuts, respectively. Thermostatically controlled gas-fueled driers limited heated air to 35 C. During drying, the maximum ambient air temperature approached that of the thermostat setting, while the minimum ambient air temperature was 21 C or greater. After drying, a conventional farmers stock cleaner was used to remove most foreign material, loose shelled kernels, and small pods that would pass through a 1.03-cm by 5.08-cm slotted screen.

Warehouses used in the study had capacities of 3850 kg of farmers stock peanuts and were 1/10 scale models of conventional warehouses. The miniature warehouses with accompanying peanut masses possessed geometric similitude but not total dynamic similitude since all factors governing dynamic similitude could not be reasonably controlled. Peanut size, ambient conditions, and fluid medium (air) are some factors which are not readily controllable to the extent of producing total dynamic similitude between miniature and full scale warehouses. Readers may wish to pursue a more detailed study in similitude of fluid flow involving heat transfer and dimensional analysis.

The warehouses, two mechanically ventilated and two naturally ventilated, were constructed using light-weight steel shapes for the super structure covered with sheetmetal of the conventional design used in peanut warehouse construction. Each mechanically ventilated warehouse had a continuously operated squirrel-cage, shaded-pole blower rated at 2.5 m^3/min at 75 Pa static pressure mounted near the ridge in the south gable giving an overspace air exchange in 1.6 min. Air entered through a 10-cm by 30-cm opening in the north gable near the ridge. Fly screen hardware cloth covered the opening. The naturally ventilated warehouses had continuous ridge vents with approximately a 5-cm wide throat opening and a continuous inlet ca. 5 cm wide under each eave. The inlet and outlet openings were covered with fly screen hardware cloth. The warehouses are shown in Figure 1.

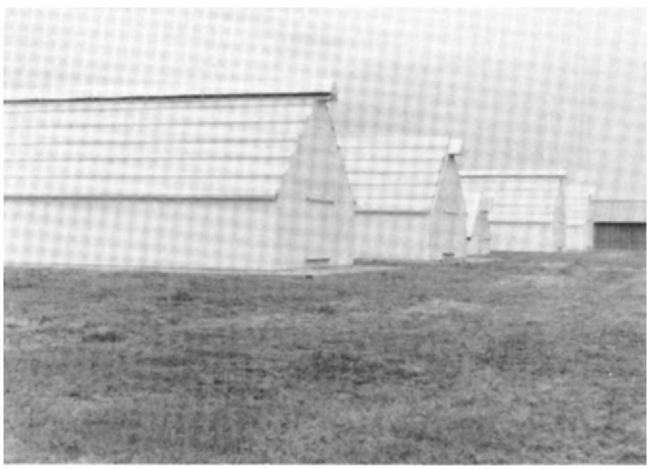

Fig. 1. Warehouses used in study, left to right, (1) naturally ventilated, 8% m.c.; (2) mechanically ventilated, 8% m.c.; (3) not used; (4) naturally ventilated, 10% m.c.; and (5) mechanically ventilated, 10% m.c.

ANSI type T thermocouples, accurate to ±0.5 C, and Phys-Chemical Research Corp. PCRC-11 humidity sensors, accurate to ±1.5% relative humidity, were used to determine temperature and relative humidity. Thermocouples, 21, and humidity sensors, 9, were located at 3 levels across the peanut mass midway the warehouse, in the overspace (one of each), and a thermocouple was located on the center of the floor. Small nylon cords supported the temperature and humidity sensors across the warehouses at 30.5-, 61-, and 91.5-cm heights. Thermocouples were spaced 45.8 cm apart beginning 15.3 cm from the wall, while relative humidity sensors were spaced 91.5 cm apart beginning 61 cm from the wall. A Monitor Labs data logger

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interfaced with a Phys-Chemical Research Corp. signal conditioner and a Techtran cassette recorder collected and stored temperature and relative humidity data at 2-hour intervals. Ambient temperature and relative humidity data were taken from a National Weather Bureau approved type weather shelter located 4 m behind the warehouses and 1.5 m above ground. Warehouse conditions during storage were determined as the means from the sensors located mid-way of the peanut mass at 30.5-, 61-, and 91.5-cm heights. Means for warehouse conditions at weekly (7-day) intervals were calculated from the 2-hour interval data for each weekly interval except for the last interval which was 5 days.

Peanuts at 10 and 8% initial m.c. were loaded into warehouses on October 2 and 3, 1986, respectively. A 13-kg sample of peanuts was taken from each warehouse at the time of filling and analyzed for aflatoxin, carbonyl content, and free fatty acid value (1,6,7). Warehouses were unloaded between March 26 and April 1, 1987. Each warehouse was unloaded into a conventional drying wagon. A pneumatic sampler was used to obtain a 13-kg sample from each wagon. A 200-g subsample was obtained from each 13-kg sample with a farmers stock riffle divider. The 200-g subsample was hand-shelled to determine moisture content using ASAE S410.1 procedure (2). The remaining portion of the 13-kg sample was shelled on a Model 4 laboratory sheller to determine shelling rate and efficiency (5). Shelled peanuts were sized into commercial categories. Duplicate carbonyl and free fatty acid analyses were performed on each size category in each sample while a single aflatoxin analysis was performed on each size category in each sample. Sensory evaluation of pastes prepared from medium and No. 1 size peanuts roasted to similar Hunter L values was performed by a 12-member panel trained in peanut flavor descriptive analysis as described by Sanders *et al.* (13). Samples were assigned intensity ratings (0-15) for descriptive terms described by Sanders *et al.* (13). A 1-kg sample was taken from the medium size category for germination tests (16) by the Georgia Department of Agriculture Seed Laboratory, Atlanta, GA.

Results and Discussion

The initial temperatures of the 8% m.c. peanuts were 32.5 and 31 C, respectively, for the naturally and mechanically ventilated miniature warehouses, while the corresponding relative humidities were 70.5 and 74.2%. Initial storage temperatures for the 10% m.c. peanuts were 30.3 and 29.5 C, respectively, for the naturally and mechanically ventilated miniature warehouses with corresponding relative humidities of 79.6 and 80.8%. The higher temperatures and lower relative humidities in the 8% m.c. peanuts resulted from the additional time in the artificial drying process.

Mean temperatures and relative humidities for ambient and warehouse conditions throughout the storage season at weekly intervals are presented in Figures 2 and 3, respectively. Mean temperatures outside the warehouses generally were lower than those inside and decreased until week 13 (Dec. 27-Jan. 2) except for a warming trend during weeks 4 and 5. The mean temperature inside the warehouses generally followed the trend of the outside ambient temperature; however, warehouse temperatures did not reach their minimum until week 17 (Jan. 24-30). As outside air cools, the cooler air drops into the peanut mass displacing the warmer lighter air within the peanut mass thereby reducing the peanut mass temperature. This phenomenon, with the insulating effect of the peanut mass, made the temperature of the peanuts lag the ambient outside temperatures.

Relative humidity is related to initital m.c. and relative humidity was ca. 10 percentage points higher in the 10% m.c. peanuts (Fig. 3). Relative humidities in all warehouses declined with time and the ca. 10% difference between the 8 and 10% initial m.c. peanuts remained until week 14 (Jan. 3-9). The 8% initial m.c. peanuts in the naturally ventilated warehouse reached the minimum relative humidity and approximated the relative humidity of the 10% m.c. warehouse by week 17 (Jan. 24-30). Relative humidity in the 8% m.c. mechanically ventilated warehouse was consistently ca. 10% lower than in warehouses with 10% m.c. peanuts. The period for minimum relative humidity in storage was reached in all other warehouses in week 17 after which relative humidity increased in all warehouses until the end of storage. Relative humidity in the naturally ventilated warehouse with 8% m.c. peanuts was somewhat irregular after the mid part of the storage season. The difference between curves for the 8 and 10% m.c. peanuts decreased with time but to a lesser degree for the 8% m.c. peanuts in the mechanically ventilated warehouse. The temperature curves for the 8% initial m.c. peanuts are very similar after week 17. Final relative humidity and moisture content of peanuts in all warehouses approached those values decribed by Beasley and Dickens (3) for equilibrium moisture contents at specific relative humidities and temperatures.

Generally, mean relative humidities within the peanut masses remained lower than the mean ambient relative humidity. During periods when the ambient relative humidity was highest, the ambient temperature was usually higher than the peanut mass temperature resulting in the high humidity air remaining above the peanut masses. When ambient temperature was lower, ambient relative humidity was also lower with cooler drier air displacing warmer moist air within the peanut masses thereby further drying the peanuts. This resulted in a lower mean peanut mass relative humidity than the mean ambient relative humidity during the cooler winter months.

There were no condensation drip lines across the peanut mass or other visible signs of free water during the storage season. No aflatoxin was detected in any of the seed size categories from any samples before or after storage. More moisture was lost from the 10% initial m.c. peanuts than from the 8% m.c. peanuts during storage (Table 1). In both instances, after storage peanut moisture contents in the naturally ventilated warehouses were higher than those in the corresponding mechanically ventilated warehouses. Some overdrying appeared to occur in the mechanically ventilated warehouses which probably took place during cold periods when the ambient relative humidity was low. A constant amount of air moved through the overspace in the mechanically ventilated warehouses. When the incoming air was cooler and more dense than the air within the peanut mass, the air within the mass was replaced by the colder drier air resulting in further drying of the peanuts. Excessive drying in storage, resulting in excessive weight and shelling losses to the owner, can be minimized in mechanically ventilated storages by use of fan controls. However, fan controls were not used in this study because most commercial warehouses do not use them except for stopping the fans for a specific period during insecticide application.

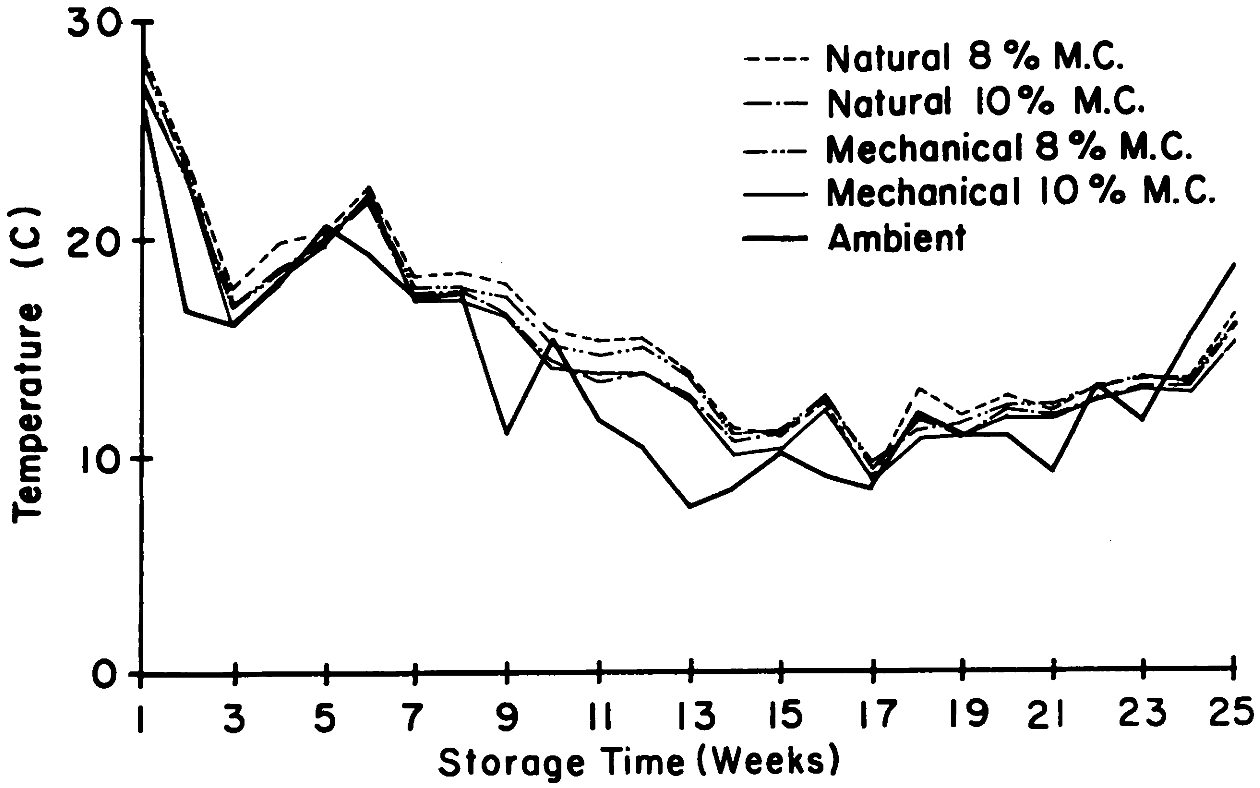

Fig. 2. Mean temperatures at weekly intervals (last interval was 5 days) during storage in naturally and mechanically ventilated warehouses beginning October 4, 1986.

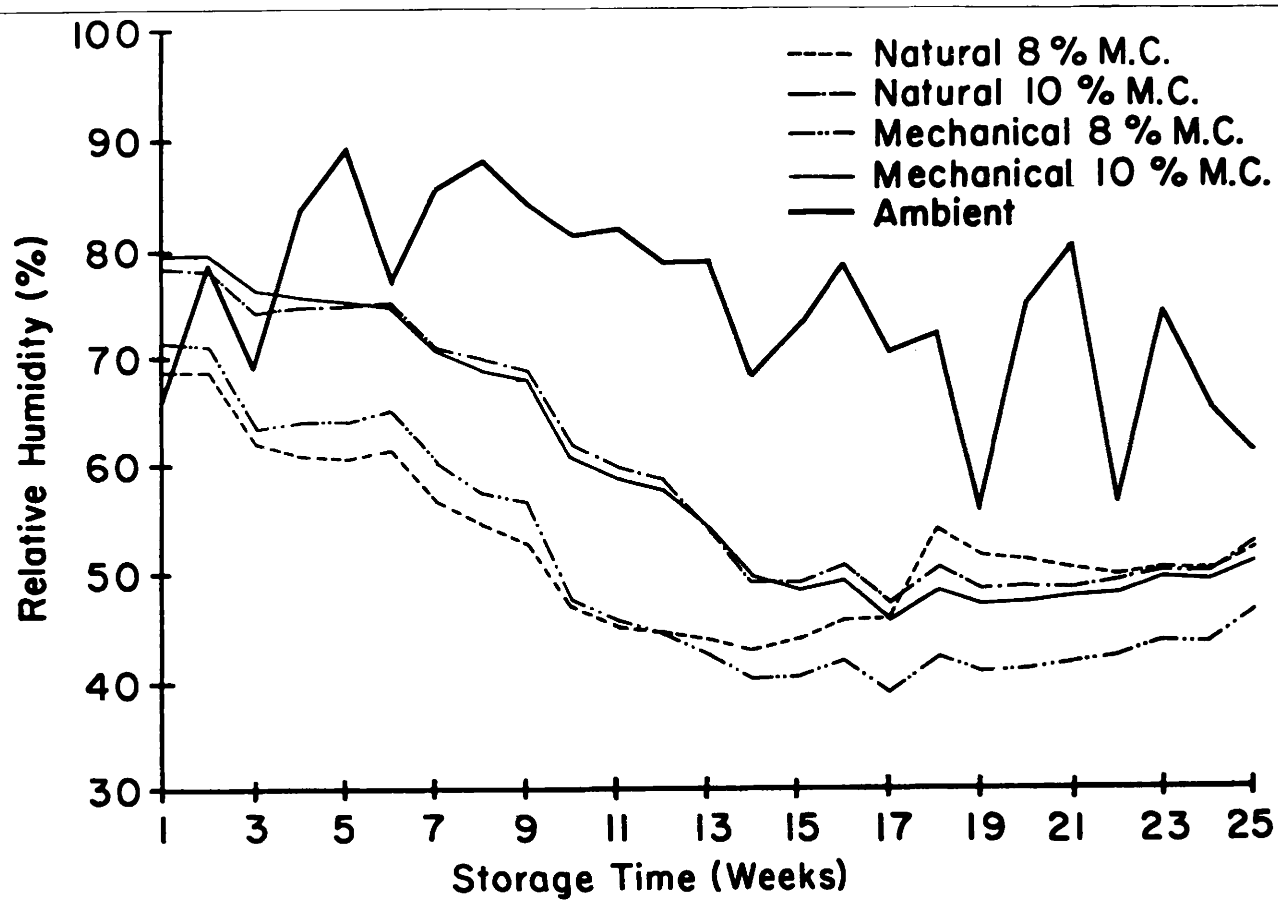

Fig. 3. Mean relative humidities at weekly intervals (last interval was 5 days) during storage in naturally and mechanically ventilated warehouses beginning October 4, 1986.

Table 1. Initial and final moisture content, shelling rate, shelling efficiency and standard deviation (SD) of farmers stock peanuts coming out of storage in naturally and mechanically ventilated miniature warehouses.

Warehouse Type	Initial Moisture Content %	Final Moisture Content %	(SD)	Shelling Rate[1] Kg/hr	(SD)	Shelling Efficiency[1] %	(SD)
Natural	8 (8.5)[2]	7.4[3]b	0.21	136.6 a	1.16	82.9 a	0.97
Mechanical	8 (8.5)	6.9 c	0.07	126.9 b	2.35	78.3 b	1.63
Natural	10 (10.0)	7.7 a	0.07	125.2 bc	1.50	83.4 a	0.14
Mechanical	10 (10.4)	7.0 c	0.08	122.0 c	2.25	80.5 b	0.70

[1]First stage sheller, No. 26 grate (1.03- x 3.18-cm slot)

[2]Moisture content going into storage.

[3]Means followed by the same letter not significantly different at P = 0.05 as determined by Duncan's New Multiple Range Test.

The carbonyl content of the various seed size categories are shown in Table 2, and the free fatty acid values for the same categories are in Table 3. Total carbonyls were slightly higher in peanuts from the 8% m.c. mechanically ventilated warehouse but all carbonyl and free fatty acid contents were within the limits considered acceptable for good storage (10). Within the two commerical sizes examined (medium and No. 1), neither initial moisture content nor storage type resulted in significant differences (P = 0.05) in intensity of peanut flavor descriptors. Mean intensities of flavor descriptors for medium and No. 1 sizes from all treatments are presented in Table 4. Intensities reported for the medium and No. 1 sizes compare favorably to descriptive flavor scores reported for carefully dried and handled medium size peanuts from mature pods (12,13). The decrease in roasted peanutty and increase in fruity/fermented from medium to No. 1 are the same type changes found between mature and immature peanuts. Taken collectively and in regard to published data, the descriptive flavor intensities indicated that all conditions examined were adequate to maintain peanut quality. Peanuts from all warehouses had identical germination percentages of 91%.

Table 2. Total carbonyls in various seed size categories for farmers stock peanuts at 8 and 10% initial moisture content going into and coming out of storage in naturally and mechanically ventilated miniature warehouses.

Seed Size Category	Carbonyls: Natural ventilation 8% m.c. In	Out	10% m.c. In	Out	Mechanical ventilation 8% m.c. In	Out	10% m.c. In	Out
	(m moles/kg oil)							
Jumbo	0.93	0.95	0.74	0.91	0.85	1.45	0.73	1.05
Medium	0.81	1.11	1.15	1.02	0.96	1.70	0.76	1.09
No. 1	1.11	1.24	1.08	1.23	1.15	1.97	1.10	1.40
OE	1.08	1.38	1.33	1.29	1.37	2.12	1.31	1.38
LSK	1.26	1.16	1.27	1.22	1.50	1.96	1.08	1.36

Table 3. Percent free fatty acids in various seed size categories for farmers stock peanuts at 8 and 10% initial moisture content going into and coming out of storage in naturally and mechanically ventilated miniature warehouses.

Seed Size Category	Free Fatty Acids: Natural ventilation 8% m.c. In	Out	10% m.c. In	Out	Mechanical ventilation 8% m.c. In	Out	10% m.c. In	Out
	(% as oleic acid)							
Jumbo	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Medium	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.12
No. 1	0.10	0.10	0.10	0.12	0.28	0.15	0.18	0.18
OE	0.13	0.20	0.15	0.20	0.10	0.32	0.13	0.17
LSK	0.18	0.10	0.20	0.18	0.18	0.30	0.10	0.37

Table 4. Mean sensory scores for medium and No. 1 size peanuts from farmers stocked stored at 8 and 10% moisture naturally and mechanically ventilated miniature warehouses.

Flavor descriptor	Medium Intensity*	No. 1
Roasted peanutty	5.9	5.4
Raw beany	2.3	2.8
Dark roasted	2.9	2.3
Sweet aromatic	3.3	3.5
Woody/hulls/skins	2.3	2.2
Cardboardy	0.3	0.3
Painty	0.0	0.1
Sweet	2.2	2.6
Sour	0.9	1.1
Bitter	1.8	1.6
Salty	0.9	0.8
Astringent	2.5	2.4
Fruity/fermented	0.3	0.7

*Intensity rating scale was 0-15.

Initial and final moisture contents, shelling rates and shelling efficiencies for the stored peanuts are shown in Table 1. In agreement with the results of Davidson *et al.* (4), shelling efficiencies were greater in the naturally ventilated warehouses having higher final moisture contents. Peanut temperatures at shelling have a much greater effect on shelling rate than moisture content (8) with shelling rate increasing as temperature decreased. Warehouses were unloaded over a 7-day period with temperature changes which no doubt had an effect on shelling rates.

Conclusion

Results from this study demonstrate that good quality can be maintained in 8 and 10% initial m.c. farmers stock peanuts in either mechanically or naturally ventilated miniature warehouses. Data suggest that mechanical ventilation incorrectly used has the potential to reduce seed moisture content to levels that impact shelling efficiencies. The storage environment maintained in all warehouses preserved seed quality with no detectable differences from warehouse ventilation types or initial moisture content. Choice of warehouse type primarily depends on management procedures and individual preference.

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