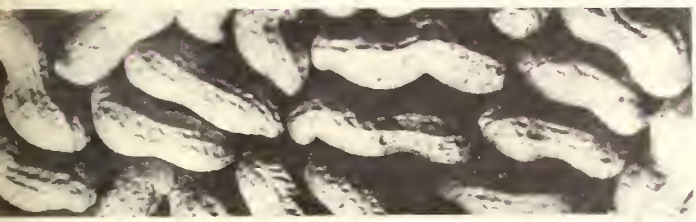
Changes in Farmers Stock Peanuts



in Storage

Marketing Significance

Agricultural Marketing Service
Marketing Research Report No. 381
Marketing Economics Research Division
UNITED STATES DEPARTMENT OF AGRICULTURE

PREFACE

This is the final report of a 5-year study which was initiated by the U. S. Department of Agriculture in 1952. This report provides information on changes in quantity and quality of farmers stock peanuts that take place in the marketing process. The study was directed toward improving methods of storing farmers stock peanuts and is a part of a broad program of research designed to reduce the cost of marketing farm products. It was conducted under cooperative agreements between Agricultural Marketing Service, the Commodity Credit Corporation, and the agricultural experiment stations of Alabama, Georgia, Texas, and Virginia. General operation of the bin sites and data collection were carried out by representatives of these experiment stations.

The Commodity Credit Corporation, through representatives of the Commodity Stabilization Service, participated in planning and advising on different phases of this study and financed the greater part of the work, including the purchase of most of the bins and equipment and all of the peanuts used in the project. The Federal-State Inspection Service participated in the sampling and grading of the farmers stock peanuts.

Special reports on important phases of the work and detailed annual reports were made available to representatives of the Commodity Credit Corporation for their use in planning and in conducting the peanut price support programs. Some of the work which has been completed and reports published include: "Storing Farmers Stock Peanuts," prepared for the 35th Annual National Agricultural Outlook Conference, November 1957 (Mimeographed); "Summary of Stored-Peanut Studies," Special Report C-310, Stored-Product Insects Section, Agricultural Marketing Service, March 1, 1958; "Peanuts Lose Weight in Storage," reprint from Highlights of Alabama Agricultural Research, Vol. 5, No. 3, Fall 1958; "Marketing Significance of Changes in Farmers Stock Peanuts in Storage," prepared for the Peanut Session of the 36th Annual National Agricultural Outlook Conference, November 1958 (Mimeographed); "Volume-Weight Relationship of Farmers Stock Peanuts Stored in Bulk," AMS-303, Agricultural Marketing Service, May 1959; "Variation in Grades of Farmers Stock Peanuts Due to Sampling," Peanut Journal and Nut World, June 1959.

February 1960

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The following persons at the participating State agricultural experiment stations assisted in the overall study, particularly in making and recording observations at the peanut bin sites: Joseph H. Yeager, agricultural economist, and Henry S. Ward, botanist, Alabama Agricultural Experiment Station, Auburn, Ala.; James L. Shepherd, agricultural engineer, Georgia Coastal Plain Experiment Station, Tifton, Ga.; B. C. Langley, superintendent, West Cross Timbers Experiment Station, Stephenville, Tex.; and H. Marshall Clark, superintendent, Tidewater Research Station, Holland, Va.

Malcolm E. Smith of the Fruit and Vegetable Division and H. M. Riley of the Federal-State Inspection Service, Albany, Ga. gave advice and assistance in the peanut grading and quality determinations.

A. M. Rollefson, agricultural economist, served as project leader from August 1952 until September 1955, when he transferred from the Agricultural Marketing Service to the Foreign Agricultural Service. During the first part of the project, Mr. Rollefson assisted in developing the detailed plan for this study and in coordinating the field work.

Leo E. Holman, agricultural engineer, Transportation and Facilities Research Division, Agricultural Marketing Service, made important contributions and gave valuable suggestions in selecting the various types of structures and other engineering phases of this study.

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Tables 10 through 34 are being published in a separate supplement to this report. They contain statistical data pertaining to the analysis of changes in quality and quantity of peanuts occurring during storage, the effect of size of lot on storability, and the effect of storage structure type and material on the keeping qualities of the peanuts. A copy of the supplement may be obtained from the Office of Information, U. S. Department of Agriculture, Washington 25, D. C.

CHANGES IN FARMERS STOCK PEANUTS IN STORAGE

Marketing Significance

By Magnus B. Johnson and C. B. Gilliland, agricultural economists
Marketing Economics Research Division
Agricultural Marketing Service

SUMMARY

During storage, farmers stock peanuts undergo changes which reduce their value, such as loss of quality and weight, damage to kernels, changes in moisture content, and losses due to insects and rodents. This final report of a 5-year study conducted by the U. S. Department of Agriculture shows the importance of these changes.

The quantity of sound mature kernels tends to decrease and the amount of damaged kernels tends to increase with length of storage, especially after the first 6 months. Therefore it generally does not pay to store peanuts as normally received from growers in ordinary storage warehouses for more than 6 months after harvesting.

Moisture content of peanut kernels when they are first placed in storage is probably the most important factor affecting storability and changes in quality. In commercial warehouses peanuts with more than 10 percent initial moisture often heat and become moldy. Under controlled experimental conditions, peanuts with initial moisture levels as high as 14 percent were stored satisfactorily, at least from picking time through the first 5 or 6 months of the marketing year. The peanuts came to a balanced moisture level within their environment in a short time after they were placed in storage. This level did not vary greatly regardless of the initial moisture of stored peanuts, and regardless of the type of storage structure, within the range of moisture levels observed in this study.

Another factor affecting storability is insect infestation. Insect damage occurred most frequently to loose shelled kernels and kernels in cracked pods. Observations of peanuts stored in bins as well as those used in laboratory tests in Tifton, Ga., indicated that insect infestation and damage to the kernels were closely associated with the condition of the peanut shells at time of storage. In fact, damage was seldom found where the pods were not cracked or broken. Infestation was present in the fall when the peanuts were harvested and continued into storage; it increased slowly during the winter months and rapidly in the late spring and summer. Without frequent fumigation, insect infestation in stored peanuts can develop to serious proportions almost overnight during warm weather.

There was no definite indication that the size or type of structure had any significant effect on quality changes during storage. However, the temperature and moisture content of peanuts fluctuated more in ventilated bins than in tight bins. Peanuts in ventilated bins lost moisture faster than those in tight bins. The temperature of peanuts fluctuated more in slatted wooden bins than in other types, and more in ventilated steel bins than in tight steel bins.

The percentage of foreign material in samples varied widely, with a slight increase during storage from pieces of broken shells and loosened soil or sand particles from the hulls. The more foreign material, the greater the insect infestation and the wider the variation in quality of samples.

The quality of the peanut kernels as indicated by the free fatty acid content remained fairly stable during the usual storage period. With only a few exceptions, free fatty acid did not exceed 1 percent. In general, the percentage of free fatty acid in the kernels increased with length of storage. Fatty acids increased most in kernels with more than 10 percent initial moisture. Oil and protein content of the peanuts showed no significant changes during storage.

Loss in dry weight of kernels varied not only by type of peanuts but also by crop years. For example, weight loss as a percentage of dry kernel weight of peanuts for the 1952 through 1956 crops of peanuts held in storage from 6 to 12 months was 2.6 percent for Southeast Runners, 2 percent for Southeast Spanish, 4.7 percent for Southwest Spanish, and 5.4 percent for Virginia type peanuts. The longer the storage period, and the higher the initial moisture content, the greater the total loss in weight.

Percentage germination of peanuts after they are removed from storage depends primarily on the kernel moisture of the peanuts at the time they were stored, the temperature of the storage environment, and the length of storage period. Germination, regardless of storage moisture, decreased with time. Peanuts of low initial kernel moisture can be stored for 5 to 6 months and still have high germination. Unshelled peanuts cannot be stored longer than 6 months without some lowering of germination, even at initial kernel moisture of 6 percent. For maintenance of high germinancy, both kernel moisture and temperature must remain low.

Total estimated cost of storing a ton of peanuts in farm-size bins for 6 to 12 months varied by type and size of bin. The total estimated cost of storage space varied from $12.65 per ton for Southeast Spanish to $26.42 per ton for Virginia type peanuts, or from 0.6 cent to 1.3 cents per pound. This was an average of about 1 cent per pound for 9 months of storage. However, in commercial operations farmers stock peanuts are stored for about 3 to 4 months. Cost is much greater the latter part of a 9-month storage period because of deterioration in quality. As expected, the annual cost per ton of capacity for large steel bins (12 and 30 tons) was lower than for small steel bins (6 tons). The cost for small steel bins was lower than that for wood frame types; their average capacities were practically identical, but the steel bins had a longer useful life and lower repair and upkeep costs.

BACKGROUND AND INTRODUCTION

The marketing of farmers stock peanuts is important to approximately 118,000 farmers in the 7 southern States producing more than 95 percent of this crop. 1/ The estimated value of the 1958 crop is about $200 million.

1/ "Farmers stock peanuts" are unshelled, uncleaned, and unsorted peanuts as they arrive at the local market from picking machines on the farm.

Peanuts rank next to cotton and tobacco as a cash crop in several of these States. Whether peanut storage by growers on the farm or in commercial warehouses would offer the farmers an opportunity to increase their earnings and whether such storage might contribute to increasing the efficiency of buyers' operations are important questions for growers, dealer, and processors.

Farmers market most of their peanuts during a 2-month period following harvest and field curing. Shellers, crushers, and other dealers or handlers (including Commodity Credit Corporation) then store this crop as farmers stock for periods ranging usually from 2 to 8 months. This crop is usually stored in the areas where produced.

During the past few years rapid changes have taken place in methods of harvesting, handling, and storing of farmers stock peanuts. There is currently a trend from bag to bulk handling in North Carolina and Virginia and also in the Southwest area (Texas and Oklahoma). In the Southeast area (Georgia, Alabama, and Florida), farmers stock peanuts have been handled and stored in bulk for many years. This labor-saving practice of handling has, within the last few years, progressed steadily in the Virginia area where over 50 percent of the crop is now handled and stored in bulk.

Storage of farmers stock peanuts presents several economic problems such as excessive loss of weight and quality due to loss of moisture, kernel damage, and insects and rodents. The immediate problem is to determine the changes in quantity and quality of peanuts occurring during storage and the extent of the loss due to the various factors.

In the marketing process, farmers stock peanuts containing varying quantities of sound mature kernels, damaged kernels, and other kernels, and variable amounts of foreign material and moisture are delivered to local buying points. Such peanuts are purchased on the basis of official grade certificates which measure these variables. After purchase, the peanuts are usually placed in storage for 2 to 8 months prior to cleaning and shelling.

This study was designed to evaluate the economic significance of changes in quantity and quality of farmers stock peanuts occurring during storage under varying conditions. Observations on physical changes in the peanuts were conducted in four important peanut-producing States: Alabama, Georgia, Texas, and Virginia.

To secure the basic data for this research, controlled experiments were conducted in the major peanut-producing areas with varying quantities of peanuts of different moisture contents. The peanuts were placed in storage bins of various types to determine: (1) Extent of shrinkage in peanuts during storage, (2) maximum moisture content at which farmers stock peanuts can be stored safely, (3) extent to which insect damage can be controlled, (4) practicability of using forced ventilation for conditioning peanuts for longer storage, (5) effect of size of lot on storability, and (6) effect of type and material of storage structure on the keeping qualities of the peanuts.

SITES AND TYPE OF STORAGE STRUCTURES

The five States in which the experimental phases of this study were conducted have different climatic conditions typical of producing areas for the three principal types of peanuts--Runners, Spanish, and Virginia. The storage experiments were established with the cooperation and at the sites of the participating State agricultural experiment stations. The major part of this research was done at Headland, Ala., with Southeast Runner peanuts; smaller experiments were made at Tifton, Ga., with Southeast Spanish; at Stephenville, Tex., with Southwest Spanish; and at Holland, Va., with Virginia type peanuts. Observations were made at the bin sites by representatives of the participating experiment stations.

At these 4 sites there were 47 storage bins of various types of construction, ranging in capacity from 2 to 30 tons. Included in the basic group were 6-ton steel bins with 3 types of ventilation, which could be used in farm storage. A more detailed description of the bins used in the study is shown in table 1.

QUANTITY AND QUALITY OF PEANUTS USED IN EXPERIMENT

Peanuts were bought each year from 1952 to 1956 for the storage tests. Most of the peanuts were sold after storage and observation for 1 year, but a few tons of those purchased each year were held in storage until the end of the tests in 1957. Quantities stored each year (including those bought in that year and those held over from previous years) are shown below.

Year purchased	Crop year 1/				
	1952-53	1953-54	1954-55	1955-56	1956-57
	Tons	Tons	Tons	Tons	Tons
1952	172	39	24	24	24
1953	---	234	39	23	23
1954	---	---	199	80	26
1955	---	---	---	116	26
1956	---	---	---	---	86
Total	172	273	262	243	185

1/ The crop year begins at different times in different areas: November 1 in Virginia-Carolina, September 1 in the Southeast, August 1 in the Southwest.

The quality of peanuts used in the experiment varied considerably by areas and by crop years.

In general, the quality of the 1952-crop Runner peanuts used in the experiment was good. Although the percentage of sound mature kernels was somewhat on the low side, probably due to dry weather, the peanuts contained very

Table 1.--Types and capacity of bins used for peanut storage study by storage sites

Location, bin type, and description	Bins	Rated capacity (bulk)	Year acquired
	Number	Tons	
Headland, Alabama			
A. Steel tanks:			
1. Perforated metal floor, tube and roof ventilation (cooling) 1/	4	6	1952
	3	6	1953
2. Perforated metal floor, mechanical ventilation (drying) 2/	3	6	1952
3. Solid metal floor, standard exhaust vent (tight) 3/	4	6	1952
	1	6	1953
B. Steel tanks:			
1. Perforated metal floor, tube and roof ventilation (cooling) 1/	2	12	1952
	1	12	1953
C. Steel tanks:			
1. Perforated metal floor, mechanical ventilation (drying) 2/	1	30	1952
D. Wood crib (10' x 10' x 8'):			
1. Tight sides, solid wood floor	2	6	1952
(rat proofed with wire mesh)	1	6	1953
2. Slatted sides, solid wood floor	2	6	1952
E. Wood (unmatched lumber);			
1. Wood siding, wood floor	1	6	4/1952
F. Wood crib:			
1. Slatted sides, wood floor (4' x 10' x 7')	2	2	4/1953
2. Slatted sides, wood floor (8' x 10' x 7')	2	5	4/1953
G. Steel tank:			
1. Solid metal floor, tube and roof ventilation (cooling) 1/	1	12	4/1953
Tifton, Georgia			
A. Steel tanks:			
1. Perforated metal floor, tube and roof ventilation (cooling) 1/	4	6	1952
	1	6	1953

See footnotes at end of table. --Continued

Table 1.--Types and capacity of bins used for peanut storage study by storage sites--Continued

Location, bin type, and description	Bins	Rated capacity (bulk)	Year acquired
	Number	Tons	
Stephenville, Texas			
A. Steel tanks:			
1. Perforated metal floor, tube and roof ventilation (cooling) 1/	4	6	1952
2. Perforated metal floor, humidity controlled installation 5/	1	6	1953
3. Perforated metal floor, mechanical ventilation (drying and humidity control) 6/	1	6	1953
Holland, Virginia			
A. Steel tanks:			
1. Perforated metal floor, tube and roof ventilation (cooling) 1/	4	6	1952
	1	6	1953

1/ A "cooling" bin has perforated metal floor, solid vertical tube connecting floor with exhaust (suction) vent with rotary head and vent.
2/ A "drying" bin has perforated metal floor with power-driven exhaust fan and standard ring-and-cone vent.
3/ A "tight" bin has a solid metal floor and standard ring-and-cone vent.
4/ Structure furnished by Alabama Agricultural Experiment Station.
5/ Moisture air conditioner that recirculates air through the bin.
6/ Equipped with fan to dry when needed and to add moisture during period of high humidity, when needed to maintain moisture at 7 to 8 percent.

little damage. This was a year of low damage and almost no curing (drying) problems. The 1953-crop Runners were somewhat lower in quality than the 1952 crop, both damage and foreign material running higher. The quality of the 1954 crop was very good, similar to the 1952 crop. The 1955-crop Runners were unusually high in quality, as was the 1956 crop.

The 1952 crop of Southeast Spanish peanuts used in the experiment, although average for the area, was low in quality. The extremely dry growing season in this area resulted in a high percentage of immature kernels. Due to the dry harvesting season, it was not possible to obtain peanuts with moisture content above 6 percent. The quality of 1953-crop Spanish type was very good, whereas in 1954, due to severe drought, peanuts of consistently acceptable quality were difficult to obtain. One load of peanuts was found to consist of 64 percent sound mature kernels and 4 percent damaged kernels (the remainder were undersize kernels or fragments). Both the 1955 and 1956 crops of this type were of fairly good quality.

Because of the drought in the Southwest, peanuts (Spanish type) used in the experiment there were of low quality, with the exception of the 1953 crop. Although this crop was short and of rather poor quality, peanuts obtained for the experiment were of good quality. In 1954 two bins were filled with peanuts which were grown under irrigation and which graded 72 percent sound mature kernels. The remainder came in small loads, ranging from 60 to 65 percent. In 1955 only one load was obtained that graded as high as 70 percent sound mature kernels. The other loads ranged from 64 to 69 percent. However, this was a year of low damage with only one load showing as much as 2 percent damage. The 1956 crop used in the experiment was also low in quality, ranging from 60 to 65 percent sound mature kernels.

The quality of the 1952-crop Virginia type peanuts in the Virginia-Carolina area used in the experiment was very good, with little or no damage. The early part of the harvesting season was excellent for field-drying peanuts, especially where they were stacked. The 1953 crop, which averaged 63 percent sound mature kernels and 3 percent damage, was considerably lower in quality than the 1952 crop. Although the 1954 and 1955 crops contained little or no damage, the percentage of sound mature kernels was somewhat low, with high percentage of immature kernels. The 1956 crop was of fairly good quality with little damage.

SAMPLING AND GRADING OF PEANUTS

In sampling, the main problem is to obtain a representative portion of a load of peanuts, including foreign material. The problem in grading is to classify properly each kernel in the sample as a sound mature kernel, damaged kernel, or other kernel; to determine properly the moisture content of the kernels; and to determine the amount of foreign material and peanut hulls.

For grading purposes, the kernels in farmers stock peanuts are grouped in three general classes. "Sound mature kernels" are the good, whole kernels which ride a screen with prescribed size openings; "damaged kernels" are those with specified objectionable defects which will ride over the same screen; and "other kernels" are all small or split kernels which pass through the same screen. Screens on which the samples were graded in this study had 15/64 x $\frac{3}{4}$ inch perforations for Runner peanuts, and 14/64 x $\frac{3}{4}$ inch perforations for Spanish peanuts. Virginia type samples were graded on a screen having 15/64 x 1 inch perforations.

All peanuts for the experiment were purchased on the basis of official grade certificates, and, as bins were filled, samples were drawn and grade analysis made on the basis of the composite sample. During the storage period, position samples were drawn from each bin at regular intervals and grade analysis made. As previously indicated, each sample was graded to determine the percentage of sound mature kernels, damaged kernels, other kernels, hulls, foreign material, and kernel moisture. As the bins were emptied, samples of peanuts were drawn and the composite sample was analyzed for grade factors. The samples were also analyzed for percentage of fatty acids and total oil, as well as amount of ammonia.

Peanuts in storage were sampled with a regular peanut sampling probe inserted through portholes at three levels in the inner door of each bin, probing from the south wall through the center. A 2-pound sample was drawn from each of six positions within a bin. 2/ The six positions were in two vertical lines, one approximately 18 inches from the door and one in the center of the bin. Each vertical line consisted of one point approximately 1 foot from the floor, one midway in the height of the pile of peanuts, and one point approximately 1 foot below the top surface of the peanuts. In Alabama, a seventh sample was drawn from the top surface of the peanuts.

During each of the storage periods, several groups of samples were checked for insect infestation. In addition to the checks on insect infestation at the regular experimental storage sites, a more complete experiment was set up by the Market Quality Research Division, Stored-Product Insects Section, in cooperation with the Coastal Plain Experiment Station at Tifton, Ga. The small scale of this laboratory experiment permitted checking of a large number

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2/ In grading the individual samples, a 2-pound lot was cleaned by hand to determine the percentage of foreign material, on a gross weight basis. From the cleaned peanuts, one-half pound was hand shelled to determine the percentages of sound mature kernels, damaged kernels, and other kernels, and the percentage of hulls. In grading Virginia type samples the percentage of extra large kernels was also determined. These percentages were computed against clean weight of sample (net weight less loose shelled kernels). A composite sample of the kernels was used to determine the moisture content of the peanuts.

of insecticide formulations and dosages. Entomological work dealt with analysis of insect abundance and species and effective control by fumigants. 3/

CHANGES IN QUALITY OF PEANUTS DURING STORAGE

Results of this experiment showed that the quality of peanuts remains about the same during the first few months of storage. The proportion of sound mature kernels tends to decrease and that of damaged kernels tends to increase, but the rate of deterioration remains low until the peanuts have been in storage for about 6 months (table 2). After 6 months the peanuts deteriorate rather rapidly.

Insect infestation can develop to serious proportions almost overnight during warm weather, unless storage bins are fumigated often. Insect infestation and the resultant damage to kernels in this experiment were closely associated with condition of the shells at the time the peanuts were stored.

Although proportions of foreign material varied widely between samples, no significant trend was noted. Of more significance than change in foreign material was the apparent effect of foreign material upon insect infestation and upon accuracy in sampling. The higher the foreign material content, the greater the insect infestation and the wider the variation in samples.

Initial moisture content of peanuts when placed in storage is probably the most important factor affecting storability and changes in quality, and, together with insect infestation, is the point around which controls center. Peanuts with more than 10 percent of initial moisture often heat and become moldy in commercial warehouses. Under controlled experimental conditions, the moisture content of peanuts came to an equilibrium level soon after being placed in storage. The level did not vary greatly regardless of the initial moisture of the stored peanuts, nor did the type of structure appear to have a large effect on it, within the range of moisture levels observed. Successive determinations of average moisture content showed only slight changes in the peanuts while in storage, but these indicated changes were small and not important commercially.

Sound mature kernels.--The 1952-crop peanuts showed some small decreases in the percentage of sound mature kernels, especially during and shortly after the hot summer months. The 1953 crop showed, in general, a consistent maintenance of sound mature kernel content during storage, although the composite samples drawn as the peanuts were moved out of the bins showed a decrease.

3/ Entomological investigations were made under the supervision of Randall Latta, formerly head of the Stored-Product Insects Section, Market Quality Research Division, Agricultural Marketing Service, and D. W. La Hue, entomologist, Stored-Product Insects Laboratory, Tifton, Ga. Findings of the entomological phases of the 5-year study on the storage of farmers stock peanuts are given in "Summary of Stored-Peanut Studies," Special Report C-310 of the Stored-Product Insects Section.

Table 2.--Average change in grade factors of farmers stock peanuts during bulk storage, by type of peanuts, 1952-56 crops 1/

Type and grade factors	Composite sample: At purchase	Composite sample: When loaded in	Average of samples from all positions: First sample from bins	Average of samples from all positions: Winter	Average of samples from all positions: After 6 months' storage	Average of samples from all positions: After 8 months' storage	Composite sample when loaded out
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Southeast Runners:							
Sound mature kernels	66.5	66.6	66.0	65.3	66.8	63.9	65.2
Damaged kernels	.8	.8	1.1	1.4	1.3	1.5	1.7
Other kernels	5.3	4.5	4.9	5.1	4.9	5.9	5.8
Foreign material	4.4	3.6	4.1	3.9	3.5	4.6	3.5
Kernel moisture	10.0	9.2	7.2	6.7	5.6	5.2	5.3
Southeast Spanish:							
Sound mature kernels	70.1	69.2	69.0	68.4	67.9	64.7	67.6
Damaged kernels	1.8	2.2	2.3	2.5	2.9	3.5	2.7
Other kernels	4.7	5.1	4.7	5.3	5.2	6.3	5.6
Foreign material	4.9	5.1	5.8	4.3	4.8	5.4	5.5
Kernel moisture	8.6	7.6	6.4	5.9	5.6	6.0	5.2
Southwest Spanish:							
Sound mature kernels	66.2	65.9	66.9	65.9	64.9	66.7	65.8
Damaged kernels	1.1	1.1	1.3	1.5	1.4	1.4	1.5
Other kernels	6.1	6.1	5.2	5.3	6.1	5.6	5.7
Foreign material	7.0	6.5	8.3	7.9	8.9	8.1	6.6
Kernel moisture	9.1	8.6	8.2	5.9	5.5	4.9	5.3
Virginia type:							
Sound mature kernels	66.2	65.9	65.6	65.4	65.8	62.2	63.7
Damaged kernels	1.2	1.3	1.4	1.5	1.3	3.9	3.5
Other kernels	3.3	3.4	3.6	3.6	3.7	3.4	3.3
Foreign material	2.6	2.9	5.6	4.6	5.5	5.0	4.9
Kernel moisture	9.6	9.6	8.6	8.1	7.6	6.8	6.7
Fancy size	72.6	75.5	70.4	70.4	64.2	73.7	69.0
Extra large kernels	34.0	33.1	30.5	30.6	30.6	32.5	30.0

1/ Data excludes bins held over for further observation, and bins on a schedule of sampling only on an "in and out" basis.

The percentage of sound mature kernels for the 1954 crop showed more fluctuations than for the previous years, with a small decrease in the percentage of sound mature kernels during storage before the hot summer months, and with a larger decrease in the composite samples drawn during the summer and as the peanuts were moved out of the bins. At Holland, Va., stored peanuts became heavily infested with insects and the percentage of sound mature kernels decreased as much as 10 percent in some lots from the last of May to mid-July.

No significant change appeared to have occurred in the quality of the 1955-crop peanuts during storage. As an average, the decrease in sound mature kernels was 2.8 percent for Southeast Runners and 1.8 percent for Southwest Spanish. In terms of the price support schedule of premiums and discounts for 1954-crop peanuts, these percentages represent decreases of $9.50 and $6.12 per ton. The decrease in sound mature kernels for Southeast Spanish and Virginia peanuts amounted to less than 1 percent.

Quality changes in the 1956 crop, as indicated by grade factors when peanuts were placed in storage and when they were removed, were not significant. The proportion of sound mature kernels remained about the same throughout storage.

Damaged kernels.--The 1952-crop peanuts did not show any appreciable change in total damage during the first few months of storage, but there was a tendency toward increasing damage later. Although damage in the 1953 crop before storage was high because of abnormal growing and harvesting conditions, there was only a slight increase during storage. During the 1952-53 and 1953-54 storage periods, the average was less than 1 percent for the season.

Findings regarding damage in the 1952 and 1953 crops were borne out by data on the 1954 crop, except at Holland, Va., where stored peanuts became heavily infested with insects. In Virginia, total damage increased as much as 8 percent, and in some of the bins the damage due to insects exceeded 10 percent.

The 1955 and 1956 crops of peanuts, which were removed from storage in the late spring and early summer of 1956 and 1957, did not show any appreciable change in total damage during the storage periods.

Other kernels.--The proportion of sound mature kernels is affected by the amount of "other kernels" as well as by the damaged kernels. The small change in the percentage of sound mature kernels during storage was accounted for by an increase or decrease in percentage of other kernels, including shrivels. The percentage of shrivels varied throughout the storage period, and there was some evidence that peanuts with low initial kernel moisture content had higher percentages of shrivels than those with higher initial moisture.

Peanuts stored from the fall of 1952 until early fall of 1953 and from the fall of 1953 until early fall of 1954 showed only minor changes in percentage of other kernels, including shrivels. The large increase for the 1953-crop Southeast Runner peanuts in Alabama, from 5.4 to 7.2 percent, does not accurately represent the condition of the peanuts through the period of

storage. The increase appeared only between the last samples drawn from the bins and the outgrade samples (samples drawn when peanuts were loaded out), with an intervening period of only 2 weeks. It was probably due to a sampling error or excessive handling.

The percentages of other kernels for the 1954 and 1955 crops showed more fluctuations than for the previous years. Again, however, sampling error or excessive handling probably accounted for the increase from 5.4 to 7.2 percent for the 1954 crop in Alabama and the decrease in Virginia from 5.4 to 3 percent, appearing only between the last samples drawn from the bins and the outgrade samples.

Peanuts stored from the fall of 1956 until late spring and early summer of 1957 did not show any appreciable change in other kernels during storage.

Foreign material.--Percentages of foreign material varied widely between samples and among positions from which samples were drawn. Variations can be attributed both to the fact that foreign material is not randomly distributed throughout the peanuts within a bin and to the manner in which the samples were taken.

In 1953-crop Southwest Spanish peanuts, there was a concentration of foreign material in the area of direct discharge from the conveyor used to fill the bins. This is the area from which center-position samples were taken, and the concentration of foreign material was reflected in that group of sample grades.

For the 1955 crop of Southeast Runner peanuts, the percentage of foreign material in the samples was less when the peanuts were loaded out than when they were loaded in. This, no doubt, was due to drying of stems, leaves, sticks, and other foreign material during storage.

Kernel moisture.--The percentage of moisture declined in all bins except those which received peanuts of less than 6 percent moisture. In the latter bins the moisture percentage increased slightly. In all bins, except the tight wooden bin, which received peanuts of greater than 8 percent moisture, the moisture content dropped to less than 8 percent after storage of 1 to 2 months. Peanuts in ventilated bins lost moisture faster than those in tight bins. High-moisture peanuts in slatted wooden bins decreased in moisture more rapidly than those stored in other types of bins.

Other than a consistent decrease in moisture, the 1952 crop showed no significant changes in quality during the storage period. In Alabama, which had a very dry storage period, a definite continuous trend downward appeared, while slight fluctuations occurred at the other sites with changes in outside humidity and temperature. In general, the favorable results obtained from the first year of the experiment were attributable to a considerable degree to the weather of that year, generally thought to be more than normally favorable to storing.

All lots of peanuts placed in storage in 1953 dried to a safe moisture level, 6 to 9 percent, in a short time (3 to 6 weeks). In Alabama and Texas,

dry weather during the 1953-54 storage period reduced the moisture content of peanuts in storage to a lower level than the year before. When the 1953 crop was removed from storage, the moisture content of peanuts stored at Headland, Ala., averaged about 4 percent as compared with about 6 percent a year earlier. For peanuts stored at Stephenville, Tex., the moisture content averaged about 4 percent, compared with about 5 percent a year earlier.

Comparison of lots placed in storage at high moisture levels with those of lower levels did not indicate any appreciable effect of initial moisture content upon other grade factors in the 1953 crop. Kernel moisture percentages were low in all bins in Alabama and Texas. Based on spring samples (May 1954), only two bins in Alabama averaged as much as 6 percent kernel moisture. All other bins were below 6 percent, with some as low as 3.7 percent. The kernel moisture was below 5 percent in all bins in Texas, with some as low as 3.8 percent. Based on composite samples when peanuts were loaded out, only one bin in Alabama averaged as high as 5 percent kernel moisture. All other bins were below 5 percent, with some as low as 3.1 percent. In Texas the kernel moisture was below 5 percent in all bins, with some as low as 3.7 percent. These low moisture levels resulted from the dry weather which prevailed during the storage period.

The 1954 and 1955 crops of peanuts placed in storage dried to a safe moisture level in a short time, with only minor fluctuations when outside humidity and temperature changed. There was some evidence that the decrease in percentage of sound mature kernels in the 1954 and 1955 crops during the storage period was related to the kernel moisture of peanuts when placed in the experimental bins.

In 1956-crop peanuts there were no indications of any appreciable effect of initial moisture content upon other grade factors. Low temperatures and high relative humidity, which prevailed during the 1956-57 storage period at Stephenville, Tex., no doubt accounted for the fact that moisture content of the peanuts was higher in 1956-57 than in earlier years. Peanuts in bins with conventional ventilation showed 7.4 and 6.5 percent kernel moisture at the end of the experiment. In other years kernel moisture in similar bins has been down to about 4 percent.

For Virginia type peanuts, the 1952 crop showed an apparent buildup in U. S. Fancy (large unshelled) peanuts and Extra Large kernels, whereas the 1955 crop showed practically no change in amounts of the two grades. Both the 1954 and 1955 crops showed a decrease in both grades, whereas the 1956 crop showed a slight decrease in Fancy peanuts but no apparent change in the amount of Extra Large kernels.

During the 1955-56 storage period, nine bins (four in Alabama, two in Georgia, one in Texas, and two in Virginia) of 1955-crop peanuts were held in storage undisturbed by sampling. That is, these bins were sampled only when loaded in and when loaded out, to check the extent, if any, to which periodic sampling of the other peanuts had disturbed their environment. No evidence that the peanuts change quality due to periodic sampling was found.

The various successive measurements of grade factors--sound mature kernels, damaged kernels, other kernels, foreign material, and moisture--in peanut samples showed no definite indication that size of bin or type of structure was responsible for any changes occurring in these measurements of quality.

Peanuts stored in various kinds of bins from the fall of 1952 until early fall of 1953 showed only minor changes in percentages of sound mature kernels and of damaged kernels. Percentage of damage increased in all bins, but it increased most in bins in which peanuts were stored with an initial kernel moisture above 10 percent.

Peanuts stored in various kinds of bins from the fall of 1953 until early fall of 1954 showed only minor changes in percentages of sound mature kernels and damaged kernels. Damage tended to increase as the period of storage increased.

Changes in quality of 1954-crop peanuts stored in various kinds of bins did not differ significantly by type of structure. There was evidence that a large portion of the decrease in percentage of sound mature kernels was accounted for by an increase in percentage of other kernels, including shrivels. Only in two bins did the percentage damage increase by 2 percentage points. Furthermore, there was some evidence that the decrease in percentage of sound mature kernels during the storage period was related to the kernel moisture content of the peanuts when they were placed in the experimental storage bins.

No significant change appeared to have occurred in the quality of the 1955- and 1956-crop peanuts during storage, regardless of the type of storage structure. The 1955-crop peanuts were removed from storage in the late spring and early summer of 1956, and the 1956-crop peanuts in 1957.

Changes in Grade Factors with Time

For the purpose of checking changes in quality and insect damage in farmers stock peanuts over a longer than normal storage period, several lots of peanuts were held over for further observations.

In Alabama 24 tons of 1952-crop Runner peanuts were carried from the first year of the experiment, 23 tons of 1953-crop peanuts were held in storage for a fourth year's observation, and 26 tons of 1954-crop peanuts were held in storage for a third year's observation. These peanuts were held in storage from 33 to 56 months.

All bins showed high total damage. Seven of the 12 bins showed total damage in excess of 2 percent. One lot of 1952-crop peanuts which were stored with an initial moisture of 9 percent and initial damage of less than 1 percent had an average of 7 percent total damage when peanuts were unloaded. No insect control measures were ever used on these peanuts. Only one bin which contained 1953-crop peanuts stored at an initial moisture of 9 percent and initial damage of 5.6 percent, showed a higher percentage of total damage.

Several lots of peanuts were held in storage for a second year's observation: Three lots of 1952- and three lots of 1953-crop peanuts, one each in Georgia, Texas, and Virginia; nine lots of 1954-crop peanuts, seven in Alabama, and one each in Georgia and Texas; and six lots of 1955-crop peanuts, five in Alabama and one in Georgia. These peanuts were held in storage from 17 to 23 months.

For the 1952- and 1953-crop peanuts stored in bins in Georgia, Texas, and Virginia, and held in storage for a second year's observation, the data indicate that in all bins, excepting one that contained 1953-crop Virginia type peanuts, the peanuts were still of good quality. The total damage in this bin, which was fairly heavily infested with insects, averaged 3 percent. In the other bins, insect infestations were light.

For 1954-crop peanuts held in storage for a second year's observation, seven of the nine bins showed total damage in excess of 2 percent. For the 1955 crop, data indicate that peanuts in all bins, with the exception of two bins in Alabama, were still of good quality. Peanuts with a moisture content of 15.4 and 13.1 percent were placed in the two bins. Tar paper was placed on the perforated metal floor of these bins to reduce air circulation. This partially explains the increase in damage which resulted.

Changes in Chemical Factors

In addition to grade analysis the samples were analyzed for percentage of fatty acids and total oil, as well as amount of ammonia. Quality changes in the 1952-56 crops of peanuts while in storage, as indicated by change in chemical analysis, are summarized in table 3.

The fatty acid content of the samples analyzed seems to remain fairly constant during the first few months of storage. Free fatty acid showed a slight increase through the storage period up to the end of the summer, when it leveled off and remained relatively stable for most of the peanuts held for a second year's observation. However, some of the holdover peanuts showed a slight increase continuing into the winter months.

Oil content of samples analyzed remained fairly constant. The determinations of oil and ammonia content indicated no definite trends and did not change appreciably.

Fatty acid values have been commonly used to evaluate deterioration and rancidity in oilseeds. The quantity of fatty acids is a measure of deterioration in peanuts that is not accounted for by commercial grade factors. It may change with age, although the commercial grade of peanuts may remain the same.

Quality changes in the 1952-crop peanuts, as indicated by chemical measurements, show that the percentage of fatty acid increased with length of storage. For all bins, this factor increased from an average of 0.41 to 0.79 percent for Southeast Spanish and from 0.22 to 0.39 percent for Southeast Runners. Peanuts stored in various types of bins from the fall of 1952 until early fall of 1953 show that the percentage of fatty acid increased most in bins receiving peanuts with initial moisture greater than 10 percent.

Table 3.--Average change in chemical analysis of farmers stock peanuts during bulk storage, by type of peanuts, 1952-56 crops 1/

Type and chemical analysis	Average of samples from all positions			
	First sample from bin	Winter	Spring	Summer
	Percent	Percent	Percent	Percent
Southeast Runners:				
Free fatty acids	0.6	0.6	0.7	0.6
Oil	49.1	47.9	48.1	47.2
Ammonia	5.8	5.7	5.8	5.8
Southeast Spanish:				
Free fatty acids	.8	.8	.9	.8
Oil	43.3	43.1	43.1	42.9
Ammonia	5.9	5.9	5.9	6.0
Southwest Spanish:				
Free fatty acids	.2	.3	.2	.3
Oil	44.8	45.7	45.8	45.8
Ammonia	6.1	6.1	5.9	6.2
Virginia type:				
Free fatty acids	.4	.3	.3	.5
Oil	44.8	44.3	44.7	45.3
Ammonia	5.6	5.6	5.7	5.7

1/ Data exclude bins held over for further observation and bins on a schedule of sampling only on loading in and loading out.

The 1952-crop peanuts showed no significant changes in total oil or ammonia content. Little variation between bins in percentage of total oil and percentage of ammonia was noted.

With the exception of the Virginia peanuts, the 1953 crop showed a somewhat higher fatty acid content than those stored from the 1952 crop. However, only four bins (three in Alabama and one in Georgia) showed an average content greater than 0.5 percent. Fatty acid content increased with length of storage for all types of peanuts. For all bins there was an increase from an average of 0.37 to 0.55 percent for Southeast Runners and from an average of 0.33 to 0.40 percent for Southwest Spanish. Although the overall averages showed very small changes, averages for certain bins indicate substantial changes in fatty acid content.

The 1953 crop stored from the fall of 1953 until early fall of 1954 showed no significant changes in total oil or ammonia content. Variations among bins in percentages of total oil and ammonia were not significant.

Quality of the 1954 and 1955 crops, as indicated by chemical measurements when peanuts were placed in storage and when they were removed, showed no significant changes in fatty acid, total oil, or ammonia. With the exception of Southwest Spanish, these crops were higher in fatty acid than the 1952 and 1953 crops. Most of the bins of peanuts showed fatty acid values of 0.5 percent or greater, and several bins averaged more than 1 percent. However, for the 1955 crop of Southeast Runners the percentage of fatty acid increased from an average of 1.25 to 1.53 whereas the Southwest Spanish increased from 0.5 to 0.15 percent.

Averages for individual bins indicated that fatty acid content varied between bins; however, the average over the storage period did not indicate any significant changes. Variations among individual bins in percentages of total oil and ammonia were not significant. All bins of peanuts of the 1956 crop, with one exception, were very low in fatty acid content, mostly under 0.5 percent. One bin in Georgia, with high-moisture peanuts, showed an average fatty acid content of 2 percent. In general, the 1955-crop peanuts were high not only in oil but also in ammonia; however, the average for all bins did not indicate any significant changes in total oil and ammonia during storage.

CHANGE IN DOLLAR VALUE PER TON

The change in value per ton of farmers stock peanuts during storage varies in accordance with the change in quality as shown by the grade. Premiums and discounts above or below the price of the base grade were determined by the extent to which the peanuts varied above or below the base grade in percentage of sound mature kernels, damaged kernels, loose shelled kernels, and, for Virginia type peanuts, extra large kernels. For this report values were calculated on the basis of the price support schedule of premiums and discounts for 1954-crop peanuts, excluding any probable discounts for loose shelled kernels. As this study was begun before loose shelled kernels were included in the pricing system, loose shelled kernels were not reported in all instances and the data on loose shelled kernels were not used. Thus, the dollar values are of clean weight of sample (net weight less loose shelled kernels).

The change in value per ton of farmers stock peanuts during storage varied not only by type of peanuts but also by crop years. In general, the value per ton decreased with length of storage, the decrease being more evident during the summer (table 4).

On the basis of grades determined from samples obtained when peanuts were placed in storage and again after 6 months of storage, the average value per ton varied considerably in accordance with the change in quality of the peanuts as shown by the grade.

For the 1952 and 1955 crops, the average value per ton after 6 months of storage was less than the value per ton of peanuts placed in storage for all types of peanuts. The average loss ranged from 2.9 percent for Southeast Spanish to 5.6 percent for Virginia type peanuts. For the 1953, 1954, and 1956 lots of peanuts, the change in value after 6 months of storage ranged from a gain of 3.3 percent for Southeast Runners to a loss of 6.8 percent for Southeast

Table 4.--Change in value of farmers stock peanuts stored in bulk for 6 to 8 months, by type, 1952-56 crops

Crop year and type of peanuts	Value per ton 1/			Percentage change in value	
	When entering storage	After 6 months' storage	After 8 months' storage	After 6 months' storage	After 8 months' storage
	Dollars	Dollars	Dollars	Percent	Percent
1952 crop:					
Southeast Runners	216.60	209.80	215.60	- 3.14	- 0.46
Southeast Spanish	229.50	220.00	198.75	- 4.14	- 13.40
Southwest Spanish	209.80	198.60	206.80	- 5.34	- 1.43
Virginia type	269.70	257.60	238.20	- 4.49	- 11.68
1953 crop:					
Southeast Runners	206.40	213.20	209.80	+ 3.29	+ 1.65
Southeast Spanish	251.50	244.50	244.50	- 2.78	- 2.78
Southwest Spanish	246.60	2/ 229.80	235.80	- 6.81	- 4.38
Virginia type	244.95	252.35	254.05	+ 3.02	+ 3.72
1954 crop:					
Southeast Runners	220.00	225.80	215.60	+ 2.64	- 2.00
Southeast Spanish	195.25	198.00	188.25	+ 1.41	- 3.59
Southwest Spanish	214.60	214.60	222.40	.00	+ 3.63
Virginia type	249.80	242.55	3/ 163.20	- 2.90	- 34.67
Average (1952-54 crops):					
Southeast Runners	214.33	216.27	213.67	+ .91	- .31
Southeast Spanish	225.42	220.83	210.50	- 2.04	- 6.62
Southwest Spanish	223.67	214.33	221.67	- 4.18	- .90
Virginia type	254.82	250.83	218.48	- 1.57	- 14.26
1955 crop:					
Southeast Runners	240.40	230.20	--	- 4.24	--
Southeast Spanish	241.50	234.50	--	- 2.90	--
Southwest Spanish	221.40	210.20	--	- 5.06	--
Virginia type	240.30	226.85	--	- 5.60	--
1956 crop:					
Southeast Runners	243.80	243.80	--	.00	--
Southeast Spanish	244.50	237.50	--	- 2.86	--
Southwest Spanish	211.20	213.60	--	+ 1.14	--
Virginia type	294.40	298.10	--	+ 1.26	--
Average (1952-56 crops):					
Southeast Runners	225.44	224.56	--	- .39	--
Southeast Spanish	232.45	226.90	--	- 2.39	--
Southwest Spanish	220.72	213.36	--	- 3.33	--
Virginia type	259.83	255.49	--	- 1.67	--

1/ Based on 1954 crop peanut price support schedule of premiums and discounts. Data do not take into consideration any probable discounts for loose shelled kernels.

2/ Peanuts not eligible for price support due to excess foreign material. Discount for each 1 percent of foreign material in excess of 10 percent was based on $1.00 per ton.

3/ Peanuts not eligible for price support due to excess damaged kernels. Discount for each 1 percent of damaged kernels in excess of 7 percent was based on $11.10 per ton.

Spanish. These changes do not include differences due to change in weight. For all lots of peanuts for the five crops, the average value per ton was less than the value of peanuts placed in storage. This average loss ranged from 0.4 percent for Southeast Runners to 3.3 percent for Southwest Spanish.

The average loss in value per ton for peanuts stored 8 months or longer ranged from 0.3 percent for Southeast Runners to 14.3 percent for Virginia type peanuts. By crop years, the change in value per ton after 8 months of storage ranged from a gain of 3.7 percent for the 1953-crop Virginia type peanuts to a loss of 34.7 percent for the 1954 crop. The latter, stored at Holland, Va., became heavily infested with insects in May and the percentage of sound mature kernels decreased as much as 10 percent in some lots over a 6-week period.

KINDS OF STORAGE LOSSES

Losses of weight in peanuts during storage may be due to loss in moisture as peanuts dry or to physical losses of peanuts either from handling or from rodents and insects. Weight loss was calculated to determine the changes in quantity of farmers stock peanuts stored for different periods of time under varying conditions. Weight loss of peanuts was determined on the basis of gross weight and dry weight of kernels for each bin. On the gross weight basis, the loss in weight was taken as the difference in gross weight of peanuts when loaded in and when loaded out, with no adjustments made for foreign material and moisture. On the dry weight basis, the loss in weight was taken as the difference in dry weight of kernels when loaded in and dry weight of kernels when removed. The loss in dry weight of kernels was calculated as follows: The amount of foreign material (based on the grade factor percentages for foreign material) was subtracted from the gross weight of peanuts placed in each bin; next, the weight of hulls (based on the grade factor percentages for hulls) was subtracted. The result was the weight of total kernels. The weight of kernels was adjusted to a dry weight basis according to the weighted average percentage of kernel moisture when the peanuts were placed in storage. When peanuts were removed from storage, the same procedure was followed in arriving at the dry weight of kernels.

Loss in Weight

The weight losses in kernels for the 5 seasons 1952-53 through 1956-57 varied between 0.5 and 3.2 percent for Southeast Runners, 0.1 and 4.6 percent for Southeast Spanish, 2.1 and 8.4 percent for Southwest Spanish, and 1.5 and 10.3 percent for Virginia type peanuts. The average storage period was about 9 months (table 5). Average weight loss as a percentage of dry kernel weight of peanuts was 2.6 percent for Southeast Runners, 2 percent for Southeast Spanish, 4.7 percent for Southwest Spanish, and 5.4 percent for Virginia type peanuts. Average loss for peanuts stored for 6 months was less than 2 percent.

The loss in dry weight of kernels varied by type of peanuts, by crop years, and by bins. Many factors influence this loss in weight. Initial moisture content, percentage of foreign material, overall kernel moisture during the storage period, initial percentages of sound mature kernels, and percentages of total

Table 5.--Loss in weight of farmers stock peanuts stored in bulk for 6 to 12 months, by type, 1952-56 crops

Crop year and type	Length of storage	Percentage loss in weight	
		Gross weight 1/	Dry weight of kernels 2/
	Months	Percent	Percent
1952 crop:			
Southeast Runners	9	4.8	3.0
Southeast Spanish	10	1.2	2.1
Southwest Spanish	11	12.5	6.8
Virginia type	9	4.2	2.6
1953 crop:			
Southeast Runners	12	8.5	2.7
Southeast Spanish	10	4.5	.8
Southwest Spanish	9	10.6	3.1
Virginia type	10	8.6	8.4
1954 crop:			
Southeast Runners	11	8.9	3.2
Southeast Spanish	11	8.3	4.6
Southwest Spanish	6	5.5	2.1
Virginia type	8	5.2	3.2
1955 crop:			
Southeast Runners	7	6.2	1.1
Southeast Spanish	9	3.3	.03
Southwest Spanish	9	6.1	8.4
Virginia type	6	8.6	10.3
1956 crop:			
Southeast Runners	9	4.1	.5
Southeast Spanish	8	4.2	2.7
Southwest Spanish	6	2.6	2.4
Virginia type	6	5.1	1.5
Average (1952-56 crops):			
Southeast Runners	9.6	7.1	2.6
Southeast Spanish	9.6	4.4	2.0
Southwest Spanish	8.2	7.3	4.7
Virginia type	7.8	6.5	5.4

1/ Difference in gross weight of peanuts when loaded in and gross weight of peanuts when loaded out.

2/ Difference in dry weight of kernels when loaded in and dry weight of kernels when loaded out.

damage. The difference in moisture of kernels and hulls was not included in the loss in weight as discussed above.

Moisture content of kernels and hulls changes with fluctuations in the environment. Therefore, in comparison with the kernel weight, the gross weight loss in handling and storing peanuts from 1952-53 through 1956-57 averaged 7.1 percent for Southeast Runners, 4.4 percent for Southeast Spanish, 7.3 percent for Southwest Spanish, and 6.5 percent for Virginia type peanuts (table 5).

Peanuts placed in storage with more than 10 percent of initial kernel moisture showed a greater loss in weight than peanuts with initial kernel moisture of 6 to 8 percent. The high shrinkage may perhaps have reflected unusually large moisture loss in hulls and foreign material as well as in kernels.

The longer the storage period, the greater was the total loss in weight of peanuts stored (table 6). Four bin lots of Southeast Runners were stored from the fall of 1952, four from the fall of 1953, four from the fall of 1954, and five from the fall of 1955 to June 1957. Average weight losses as a percentage of the dry kernel weight of peanuts when placed in bins were 7.1, 4.4, 3.8, and 4 percent for the four crops. In one lot of 1952-crop peanuts, the loss was 10.4 percent of the dry weight of kernels placed in the bin almost 5 years earlier. No insect control measures were taken on these peanuts. This indicates that insect control in peanuts is necessary if weight loss is to be minimized and quality maintained.

Average weight loss as a percentage of dry kernel weight of peanuts held in storage for a second year ranged from 4.4 to 7.5 percent for the Virginia peanuts, from a gain of 0.6 percent to a loss of 5 percent for Southeast Spanish, and from a slight gain of 0.1 percent to a loss of 3.1 percent for Southwest Spanish (table 6).

Insects play a major part in weight loss of stored peanuts. Kernel damage due to insects rose to 2.7 percent after 6 months of storage, and to 5.6 percent after 9 months. This did not include loose shelled kernels, many of which were completely destroyed. It is estimated that weight loss due to insect damage averaged from about 1 percent for peanuts stored for 6 months to 3 percent for those stored 9 months or longer.

Rats and mice, if not controlled, also are responsible for considerable reduction of quality during storage. In addition, the peanuts may become contaminated and unfit for use as food.

MILLING LOSS

Different crops of peanuts stored in the experimental bins were shelled to determine the milling loss. Peanuts from each bin were weighed and graded before shelling, processed separately, and the bin identification maintained. After shelling, the component parts, that is, foreign material, hulls, and total meats, were weighed. The difference in weight of unshelled peanuts and final total weight of the component parts after shelling was designated as mill loss. Accurate weight of foreign material and hulls could not be obtained for

Table 6.--Loss in weight of farmers stock peanuts stored in bulk for 19 to 55 months, by type, 1952-55 crops

Crop year and type	Length of storage	Percentage loss in weight	
		Gross weight 1/	Dry weight of kernels 2/
	Months	Percent	Percent
1952 crop:			
Southeast Runners	55	8.3	7.1
Southeast Spanish	21	2.8	+.6
Southwest Spanish	21	5.4	+.1
Virginia type	21	9.7	7.5
1953 crop:			
Southeast Runners	45	7.8	4.4
Southeast Spanish	19	.3	1.9
Southwest Spanish	20	4.7	2.3
Virginia type	21	+.1	4.4
1954 crop:			
Southeast Runners	27	9.3	3.8
Southeast Spanish	20	4.0	.2
Southwest Spanish	19	3.8	3.1
1955 crop:			
Southeast Runners	21	11.7	4.0
Southeast Spanish	20	11.3	5.0

1/ Difference in gross weight of peanuts when loaded in and gross weight of peanuts when loaded out.

2/ Difference in dry weight of kernels when loaded in and dry weight of kernels when loaded out.

some lots. Thus, the amount of foreign material and hulls was based on the outgrade percentage calculated from samples converted to pounds for these lots.

The average mill loss was about 1.58 percent during the 5-year period. The losses varied by type of peanuts and also by crop years (table 7). For Southeast Runner peanuts the average mill loss ranged from 1.1 percent for the 1952 crop to 2.2 percent for the 1953 crop. The 1953-crop peanuts were somewhat lower in quality than the 1952 crop, both damage and foreign material being higher.

For Southeast Spanish the change in weight during milling ranged from a small gain of 0.2 percent for the 1953 crop, which was unusually high in quality, to a loss of 1.4 percent for the 1955 crop. For the Virginia type peanuts the average loss ranged from 0.8 percent for the 1952 crop to 2.8 percent for

Table 7.--Milling loss of farmers stock peanuts stored in bulk for 6 to 12 months, by type, 1952-56 crops

Crop year and type	Length of storage	Milling loss 1/
	Months	Percent
1952 crop:		
Southeast Runners	9	1.11
Southeast Spanish	10	.45
Virginia type	9	.84
1953 crop:		
Southeast Runners	12	2.17
Southeast Spanish	10	+.20
Virginia type	10	2.16
1954 crop: 2/		
Virginia type	8	2.83
1955 crop:		
Southeast Spanish	9	1.41
Southwest Spanish	9	.45
Virginia type	6	2.08
1956 crop:		
Southwest Spanish	6	3.70
Virginia type	6	1.99

1/ Difference between weight of farmers stock peanuts before shelling and the final weight of components after shelling.
2/ Only Virginia type shelled and results reported in 1954.

the 1954 crop. For the Southwest Spanish the loss ranged from 0.5 percent for the 1955 crop to 3.7 percent for the 1956 crop. The average mill loss as calculated for each bin, based on the difference in weight of peanuts taken from each bin and the total weight of components after shelling, varied considerably by bins.

For the 1955 crop shelled, the average mill loss by bins ranged from 0.6 to 2.2 percent for Southeast Spanish, from 1.5 to 2.4 percent for Virginia peanuts, and from a gain of 1 percent to a loss of 3.2 percent for Southwest Spanish.

For the 1956 crop shelled, the average mill loss by bins ranged from 0.2 to 5.5 percent for Southwest Spanish, and from a slight gain of 0.1 percent to a loss of 3.3 percent for Virginia type peanuts.

Milling loss, as calculated for each bin, was not closely related to moisture content of peanuts at the time of storage. Apparently the losses were more closely related to the efficiency of the mill than to changes in quality of the peanuts during storage.

GERMINATION OF STORED PEANUTS

Germination is described in this report as the percentage of sound mature kernels developing sprouts in germination tests on peanut samples taken from the bins. Germination, like fat acidity, measures deterioration in peanuts that is not accounted for by commercial grade factors. Both fat acidity and germination may change with age, although the commercial grade of the peanuts may remain the same.

Germination in all bins, regardless of storage moisture, decreased with time. However, there was a definite relationship between initial kernel moisture and loss in germination. The lower the kernel moisture of peanuts when placed in storage, the greater are the chances for good germination at the end of the storage period. For high germination at planting time, peanuts should be stored with initial moisture of about 7 percent or less. Unshelled peanuts cannot be stored longer than 6 months without lowering germination, even at initial kernel moisture of 6 percent.

To determine effects of storage on seed viability, germination tests were made at the time of storage in the fall, at the normal time of planting in early spring, and also in late summer. Germination tests were run on a composite sample of peanuts to arrive at a percentage for each bin. Because the period of dormancy varies in different types of peanuts, the schedule of germination tests varied at the different storage sites. Spanish peanuts have little or no dormancy requirement, while Virginia and Runner types require a period of after-ripening before they will germinate.

Germination percentages for Southeast Runners and Southwest Spanish peanuts after 5 and 8 months of storage are given in table 8. Rates of decrease in percentage of germination were smaller for Southwest Spanish than for Southeast Runner peanuts.

At the Alabama site, germination of the 1952 crop for peanuts with less than 6 percent initial kernel moisture was 91.3 percent after a 5-month storage period, and 74 percent after 8 months. For peanuts with initial kernel moisture above 6 percent, germination percentages were considerably lower.

At the Texas site, storage conditions were satisfactory for maintaining high germination. As in the Alabama bins, peanuts with high initial moisture showed the greatest loss in germination. The exception was the 1953 crop, perhaps because of sampling error or germination technique.

A general conclusion presented in a publication on germination by Alabama Polytechnic Institute, which used data developed by this experiment together with data developed under other projects, stated that "germination of seed peanuts after storage is largely dependent on the kernel moisture content at

Table 8.--The effect of initial kernel moisture on the germination of peanuts stored in bulk, by type and crop year 1/

Type, crop year, and initial kernel moisture	Germination		
	First sampling from bins	After 5 months' storage	After 8 months' storage
	Percent	Percent	Percent
Southeast Runners:			
1952 crop:			
Less than 6.0 percent	88.3	91.3	74.0
6.0 - 7.9 percent	94.6	82.9	68.6
8.0 - 9.9 percent	88.0	74.2	53.2
10.0 - 11.9 percent	82.0	62.0	26.8
12.0 percent and over	50.0	66.0	36.0
1953 crop:			
Less than 6.0 percent	---	---	---
6.0 - 7.9 percent	69.0	73.5	46.5
8.0 - 9.9 percent	62.2	53.5	34.3
10.0 - 11.9 percent	54.4	65.9	39.6
12.0 percent and over	60.7	59.5	33.5
1954 crop:			
Less than 6.0 percent	69.5	58.5	---
6.0 - 7.9 percent	54.0	47.0	---
8.0 - 9.9 percent	---	---	---
10.0 - 11.9 percent	43.5	43.0	---
12.0 percent and over	48.1	44.6	---
Southwest Spanish:			
1952 crop:			
6.0 - 7.9 percent	91.0	86.5	93.0
8.0 - 9.9 percent	92.0	84.0	95.0
10.0 - 11.9 percent	88.0	77.0	92.0
1953 crop:			
6.0 - 7.9 percent	96.5	95.5	---
8.0 - 9.9 percent	98.5	99.0	---
10.0 - 11.9 percent	80.0	93.0	---
1956 crop:			
6.0 - 7.9 percent	---	---	---
8.0 - 9.9 percent	73.0	73.0	---
10.0 - 11.9 percent	70.0	67.7	---

1/ Germination was based on an average of samples from all positions, whereas initial kernel moisture is a composite of samples when loaded into storage.

which the peanuts are stored, the temperature of the storage environment, the length of storage period, and whether stored shelled or unshelled. The results of this study show that unshelled peanuts could be stored either under controlled conditions or in farm-type bins for a period of 5 months, during which temperatures remained below 96° F. and still have a high germination percentage, provided the peanuts had an initial kernel moisture content of 7 percent or less. If seed peanuts are to be stored for a period longer than 5 months, a means of holding temperatures below 76° F. should be a part of the storage structure." 4/

This means that temperature controls in storage structures are not needed for seed peanuts if they are not held beyond planting time. For longer storage some means of holding temperatures below 76° F. must be a part of a storage structure.

TEMPERATURES OF PEANUTS IN STORAGE

High temperatures in peanut storages lower germination, increase free fatty acid, and increase insect activity with resulting damage to peanut kernels. These factors in turn lead to lower values.

Temperature readings were taken at regular weekly intervals in all storage facilities. 5/

Temperatures within bins were found to follow prevailing outside temperatures although the changes were not so abrupt nor so great. Likewise, little difference was found in peanut temperatures as between large and small bins although temperature change in small bins occurred more rapidly. However, the difference is small and has no particular advantage for maintaining the quality of stored peanuts. There appeared to be no significant fluctuations in any of the bins that could not be accounted for by change in atmospheric temperatures. Temperatures in ventilated bins fluctuated more than in tight bins and more nearly followed atmospheric temperatures (figs. 1 to 4).

Peanuts in large bins are slightly cooler in the summer and warmer in the winter than those stored in small bins. For this reason large bins may present an advantage during the summer, but not during the winter when low temperatures are desired for killing insects.

4/ "Factors Affecting Germination of Runner Peanuts," Bul. No. 289, Agricultural Experiment Station of the Alabama Polytechnic Institute in cooperation with United States Department of Agriculture, Agricultural Research Service, June 1954.

5/ Temperatures were recorded by placing thermocouples at nine locations in each bin. The nine locations were at three levels, running from south to north through the center of the bin. The three levels were 1 foot from the floor, midway in the height of the pile of peanuts, and 1 foot below the top surface of the peanuts, with the two end thermocouples each 1 foot from the wall and the third one in the center. Additional thermocouples were placed in the large 30-ton steel bin to more adequately cover the large mass of peanuts.

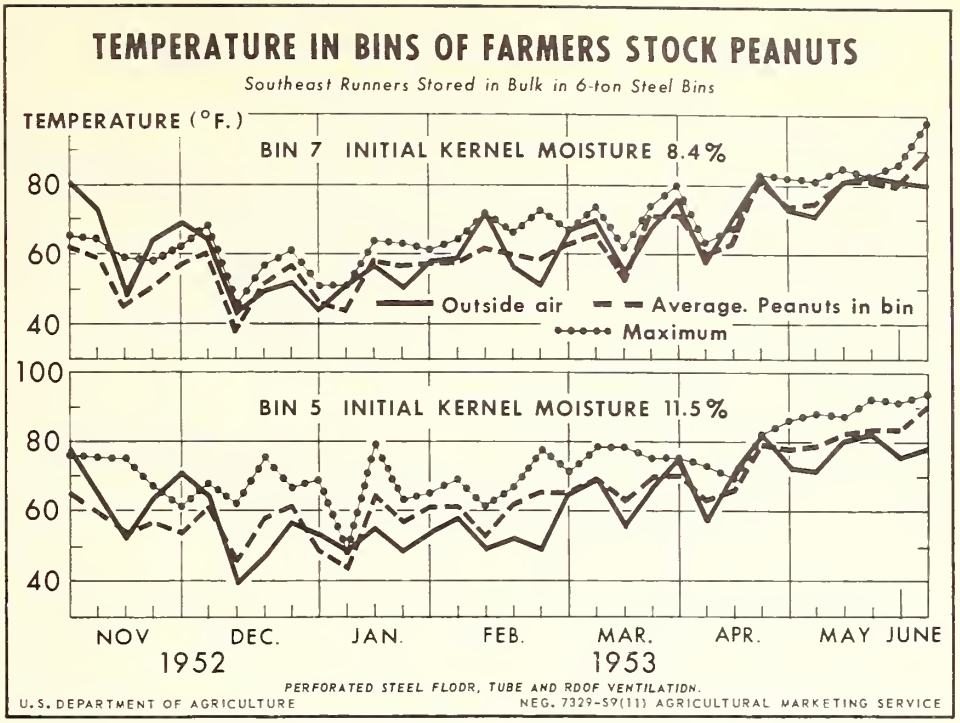

Figure 1

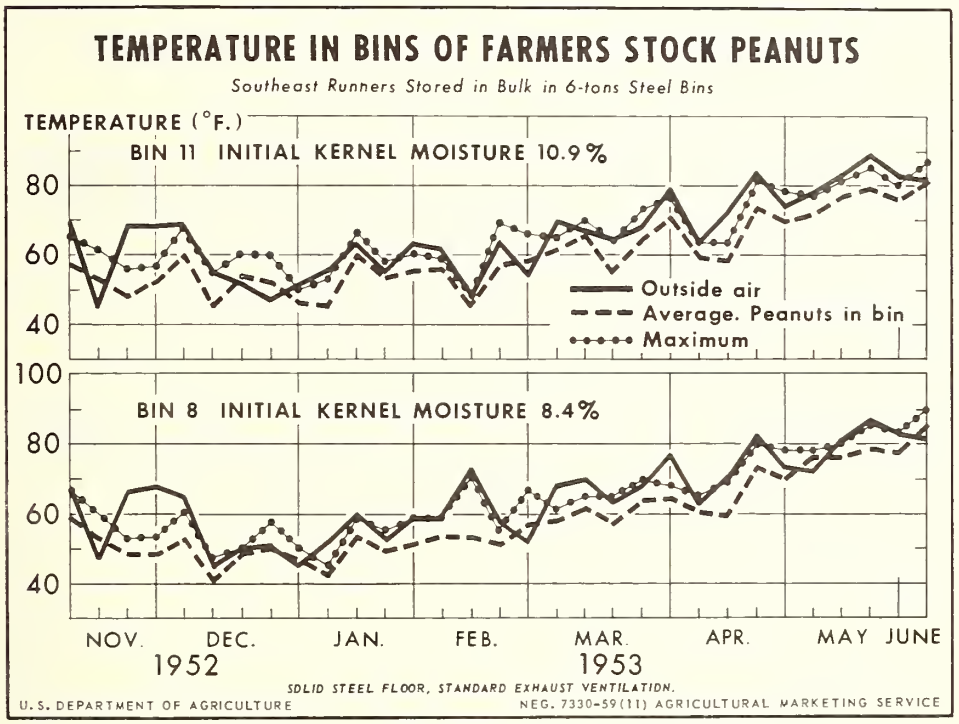

Figure 2

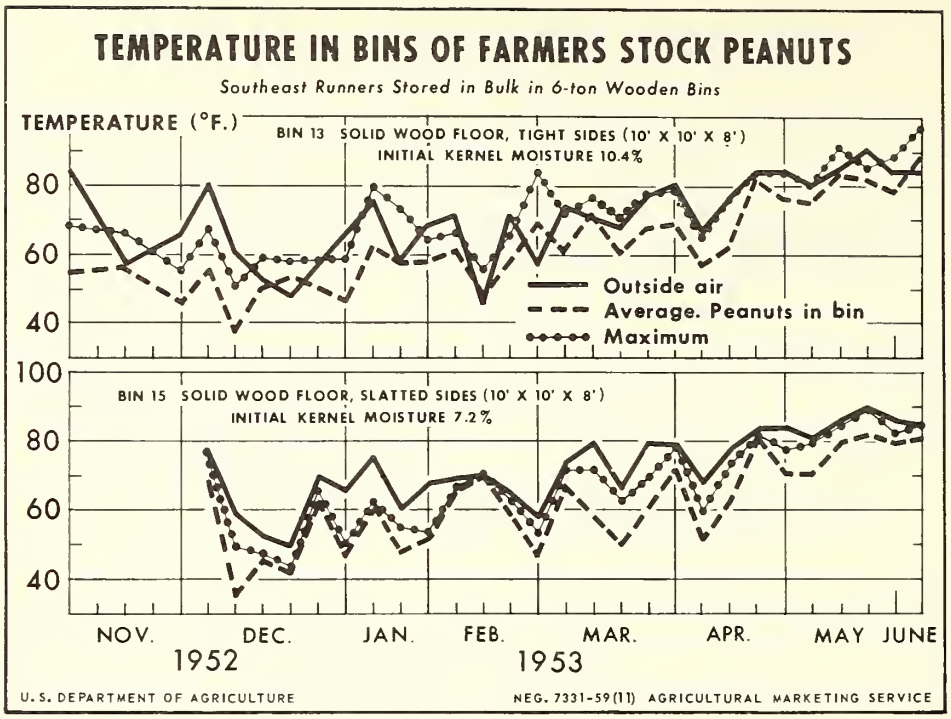

Figure 3

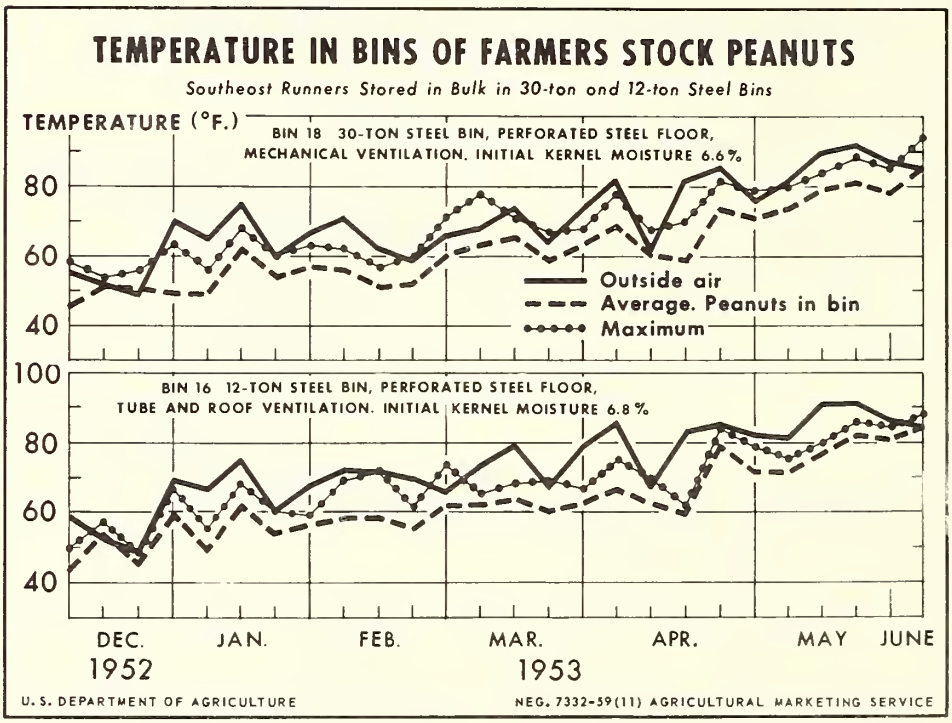

Figure 4

ESTIMATED STORAGE COSTS PER TON OF PEANUTS

Over a period of time, the annual use cost of steel bins is less than that of wooden bins because of a longer useful life and lower repair and upkeep costs (table 9). This clearly indicates the marked advantage of the steel type of structure for long-term investments in farmers stock peanut storage facilities. Large steel bins have a lower annual use cost per ton of storage space than small steel or wooden bins. Farmers and others who need storage space for peanuts should consider one or two larger bins or storage structures consistent with their needs as compared with several small bins.

Shrinkage losses were found to vary with peanut type and length of storage. For the five seasons from 1952-53 through 1956-57, the estimated weight loss (dry weight basis) in farmers stock peanuts when held in storage for a period ranging from 6 to 12 months, averaged 2.6 percent for Southeast Runner peanuts, 2 percent for Southeast Spanish, 4.7 percent for Southwest Spanish, and 5.4 percent for Virginia type peanuts. At 1958 support prices, shrinkage losses in storing peanuts averaged $5.20 per ton for Southeast Runner peanuts, $4.36 per ton for Southeast Spanish, $9.85 per ton for Southwest Spanish, and $12.15 per ton for Virginia type peanuts. There were only small losses in peanuts stored for less than 6 months, and very little difference between areas.

Assuming an overall decrease of 1 percent in sound mature kernels and 1 percent increase in total damage during storage, losses due to deterioration were calculated on the basis of the 1958 peanut price support schedule. This amounts to a decrease in value per ton of $6.16 for Southeast Runner peanuts, $6.27 for Southeast Spanish, $6.22 for Southwest Spanish, and $6.30 for Virginia type peanuts.

Total estimated cost of storing a ton of peanuts in various kinds of small bins varied by type and size of bins. Total estimated cost per ton of storage space, excluding the cost of moving the peanuts into and out of storage, varied from $13.72 to $17.79 per ton for Southeast Runner peanuts, from $12.65 to $16.15 per ton for Southeast Spanish, from $18.10 to $21.59 per ton for Southwest Spanish, and from $21.36 to $26.42 per ton for Virginia type peanuts.

Table 9.--Estimated costs of storing farmers stock peanuts in various kinds of small bins, by type of peanuts

Item	Standard steel bins			Wooden bins 10 ft. x 10 ft. x 8 ft.	
	10 ft. dia. x 8 ft. high	14 ft. dia. x 8 ft. high	18 ft. dia. x 16 ft. high	Tight sides	Slatted sides
	Dollars	Dollars	Dollars	Dollars	Dollars
Estimated cost of bins	360.00	475.00	1,100.00	390.00	410.00
Annual use cost:					
Annual depreciation 1/	12.00	15.80	36.67	19.50	20.50
Interest on average investment at 4 percent	7.20	9.50	22.00	7.80	8.20
Repair and maintenance 2/	1.80	2.38	5.50	7.80	8.20
Taxes and insurance 3/	5.40	7.12	16.50	5.85	6.15
Total	26.40	34.80	80.67	40.95	43.05
	Tons	Tons	Tons	Tons	Tons
Capacity of bins:					
Southeast Runner	5.3	10.3	34.2	6.7	6.7
Southeast Spanish	6.2	12.0	39.9	7.8	7.8
Southwest Spanish	6.1	12.0	39.8	7.8	7.8
Virginia type	4.3	8.4	27.7	5.4	5.4
	Dollars	Dollars	Dollars	Dollars	Dollars
Annual use cost per ton:					
Southeast Runner	4.98	3.38	2.36	6.11	6.43
Southeast Spanish	4.26	2.90	2.02	5.25	5.52
Southwest Spanish	4.33	2.90	2.03	5.25	5.52
Virginia type	6.14	4.14	2.91	7.58	7.97
Cost of shrinkage per ton: 4/					
Southeast Runner	5.20	5.20	5.20	5.20	5.20
Southeast Spanish	4.36	4.36	4.36	4.36	4.36
Southwest Spanish	9.85	9.85	9.85	9.85	9.85
Virginia type	12.15	12.15	12.15	12.15	12.15
Cost of change in grade per ton: 5/					
Southeast Runner	6.16	6.16	6.16	6.16	6.16
Southeast Spanish	6.27	6.27	6.27	6.27	6.27
Southwest Spanish	6.22	6.22	6.22	6.22	6.22
Virginia type	6.30	6.30	6.30	6.30	6.30
Total estimated cost per ton:					
Southeast Runner	16.34	14.74	13.72	17.47	17.79
Southeast Spanish	14.89	13.53	12.65	15.88	16.15
Southwest Spanish	20.40	18.97	18.10	21.32	21.59
Virginia type	24.59	22.59	21.36	26.03	26.42

1/ Based on estimated life of 30 years for the steel bins and 20 years for the wooden bins.

2/ Estimated to be 0.5 percent of original cost for steel bins and 2.0 percent for the wooden bins.

3/ Estimated to be 1.5 percent of original cost.

4/ Based on 5-year average loss in weight, dry weight basis, of 1952-56 crops of peanuts stored in experimental basis for a period ranging from 6 to 12 months. Value per pound based on the 1958 peanut price support schedule.

5/ Based on an overall decrease of 1.0 percent for sound mature kernels and an overall increase of 1.0 percent in total damage. Values were based on the 1958 peanut price support schedule.

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