Shrinkage of Farmers Stock Peanuts During Storage[1]

Christopher L. Butts* and John S. Smith, Jr.[2]

ABSTRACT

A 3-yr study was conducted during crop years 1989-91 to determine the value loss (shrinkage) experienced during long-term storage of farmers stock peanuts. Typical warehouses used to store each of the three major peanut market types were selected in each of the peanut production regions of the United States. Peanuts were purchased and stored according to conventional operating procedures for at least 60 d, unloaded, and hauled to the shelling plant (regrade). The loan value of the peanuts was determined using the 1990 Peanut Loan Schedule based on official grades and weights at load-in, bailout, and the shelling plant. Data from samples shelled at the National Peanut Research Laboratory Pilot Shelling Plant were used to determine the difference between outturns estimated from the official grade and the actual shelling outturns after storage. The 3-yr average change in value from load-in to regrade for runner peanuts was -2.04%; spanish peanuts was -2.81%; and virginia peanuts was -4.17%. Increases in foreign material and loose shelled kernels due to handling during loading and unloading, and changes in the kernel size distribution contributed equally to the value loss for the runner peanuts. Moisture loss to levels below 7% was responsible for approximately 20% of the value loss in both the spanish and virginia peanuts. Redistribution of kernel size, primarily the increase in split kernels, resulted in approximately 25% of the loss experienced in virginia-type peanuts. An increase in foreign material percentage accounted for approximately 50% of the virginia peanut value loss. Increased foreign material and loose shelled kernels accounted for approximately 66% of the loss experienced in the spanish peanuts. The total kernel weight obtained when the peanuts were shelled averaged 1.5% less than that estimated from the official grades at the time of original purchase. All market types had decreased outturn of whole edible kernels and increased split kernels. A net decrease in edible kernel outturns of 1.3% was observed.

Key Words: Warehouse, storage, shrink, peanuts, farmers stock, value, grade, quality, foreign material, moisture content.

Farmers stock peanuts have their peak quality at harvest. Current post-harvest handling and storage procedures were developed with the goal of maintaining that quality. Farmers stock peanuts are typically marketed in 2.7- to 4.5-t lots with an average moisture content ranging from 8 to 10% wet basis (wb). The value of the farmers stock peanuts is determined by inspectors hired by the Federal State Inspection Service and based upon the amount of foreign material (FM), loose shelled kernels (LSK), sound mature kernels (SMK), sound splits (SS), other kernels (OK), and damaged kernels (DK), and the average moisture content of peanut kernels (excluding LSK) in the load. If the moisture content of the peanuts is above 7% at the time of marketing, the marketed weight is adjusted to 7%. No adjustments are made for peanuts below 7% moisture content. Harvest typically lasts from 1 Sept. until 30 Oct.

After the farmers stock peanuts are purchased, many of them are placed in bulk storage warehouses for up to 10 mo. While in storage, the peanuts reach a moisture content in equilibrium with the temperature and relative humidity of the surrounding air (12). Either mechanical or natural ventilation systems remove excess heat and moisture from the warehouse. A properly designed and installed ventilation system provides sufficient airflow through the overspace to prevent condensation or excessive temperatures in the peanut mass. Under ideal conditions, the peanuts will have a moisture content of approximately 7% when unloaded. Unloading, referred to as "bailout" by the industry, usually begins in February or March and lasts 1 to 3 wk. However, bailout may begin as early as a few weeks after loading or as late as June.

Even in ideally managed warehouses, the peanuts suffer some loss in quality. These changes are caused by mechanical damage during loading and unloading (10), decrease in actual kernel size due to moisture loss (2,11), and loss in marketable weight caused by moisture loss to a moisture content less than 7%. Under less than ideal situations, condensation in the warehouse may wet the peanuts. Mold growth may occur on the wetted peanuts rendering them unsuitable for human consumption (5). Excessive physical damage can result from improper operation and maintenance of handling equipment. Peanuts may be crushed while unloading with the front-end loader. The value loss will vary widely from warehouse to warehouse depending upon initial peanut quality, warehouse loading and unloading practices, warehouse maintenance, ventilation system operation, and ambient environmental conditions.

Under current regulations, U.S. peanut shellers must deliver quota peanuts to the shelling plant based upon the farmers stock value at the time of purchase less an allowance for shrink. Shellers that have purchased peanuts for export must certify that those peanuts have been exported or crushed for oil. The amount of peanuts that a sheller must export or crush is determined by calculating the weight of SMK, SS, oil stock (OS), and the total kernel content (TKC) originally purchased. The export/crush obligation for the sheller is the weight of each component (SMK, SS, OS, and TKC) originally purchased less the allowable shrink. If this allowance is set too low, and the value loss during storage in well-main-

[1]This project was conducted in cooperation with USDA-AMS, USDA-FSIS, and the Commodity Credit Corporation at the request of USDA-ASCS, Tobacco and Peanuts Division.

[2]Agric. Engineers, USDA, ARS, National Peanut Research Laboratory, Dawson, GA 31742.

*Corresponding author.

tained facilities is greater than allowable, then excessive monetary losses are experienced by the sheller. However, if the allowance is set too high, and the value loss during storage is less than the allowance, then the Commodity Credit Corporation (CCC) experiences a loss that did not occur (1,8). Recently, there have been considerable differences of opinion regarding the proper shrink allowance.

The USDA, Agricultural Stabilization and Conservation Service (ASCS) requested that the USDA-ARS undertake a 3-yr project to determine the actual value loss of peanuts in an "average" peanut storage facility in each of the three peanut-growing regions of the U.S. The goals of this study were to determine the (a) change in value of farmers stock peanuts during storage over a typical duration (October to February), (b) difference in value change caused by year-to-year variation in peanut quality and environmental conditions, and (c) causes for the change in value of farmers stock peanuts during storage.

Materials and Methods

Four peanut warehouses were selected in the three U.S. peanut production regions according to the relative amount of peanuts produced in each region. Two warehouses were located in the Southeastern U.S. for runner-type peanuts (Anderson's Peanuts, Troy, AL; Curry Farm Supply, Shellman, GA), one in the Southwestern U.S. for spanish-type peanuts (Golden Peanut Company, DeLeon, TX), and one in the Virginia/Carolina area for virginia-type peanuts (Edgecombe-Pitt Cooperative, Conetoe, NC). Each warehouse was selected based upon the physical condition of the warehouse, the availability of equipment to obtain official grade samples from truck trailers, and the willingness of the warehouse owners and shellers to cooperate. Detailed descriptions of each warehouse are given in Table 1 and loading and unloading dates are given in Table 2.

After the peanuts were inspected, they were purchased and placed in storage according to customary procedures. The official grade was recorded on the AMS-FV95 form, the weight of the individual load of peanuts recorded, then marketed and accounted for using the ASCS-1007 form. A representative of the area association (GFA, SWPGA, or PGCMA) recorded the trailer number of each load of peanuts emptied into the dump pit and subsequently loaded into the subject warehouse. The inspectors set aside copies of the official grade notesheet (FV95) for each lot of peanuts loaded into the warehouse. Copies of the ASCS-1007 corresponding to each FV95 were obtained. Inspectors retained the SMK+SS or TSMK, OK, and the LSK from official grade samples in separate storage containers. The samples of each kernel type were blended with those of the same kernel type for a daily composite sample of the TSMK, OK, and LSK, respectively. These samples were then divided and the moisture content of each subsample recorded.

This stage of the study was denoted as the "load-in" stage. It should also be noted that the Alabama warehouse was filled to about one-third capacity during the 1990 crop year due to a severe drought in the Southeastern U.S.

At the end of load-in, the association representative sealed all points of entry through which peanuts could be unloaded. Seal numbers were recorded. The doors and drawports remained sealed until the shelling plant was ready to receive the peanuts from the subject warehouse. The ventilation system was operated to control condensation and remove excessive heat and moisture from the warehouse according to the owner's normal procedure. Insecticides were dispersed in the warehouse according to

Table 1. Physical description of warehouses used in 3-yr study to determine the value loss of farmers stock peanuts during storage.

	Troy, AL	Shellman, GA	Conetoe, NC	DeLeon, TX
Distance to shelling plant (km)	24[a]	56	64	13
Peanut type	Runner	Runner	Virginia	Spanish
Design capacity (t)	1814	3720	2177	2903
Length (m)	30.5	43.6	30.5	61.0
Width (m)	18.3	24.4	24.4	18.3
Eave height (m)	7.3	7.3	7.3	5.5
Roof pitch	9:12 w/doghouse	12:12	9:12 w/doghouse	12:12
Ridge orientation	North-South	North-South	East-West	East-West
Ventilation	Natural	Mechanical	Mechanical	Mechanical
Partitioned	Yes	Yes	No	No
Loading equipment	20 m bucket elevator to horizontal belt conveyor w/tripper mechanism	27 m bucket elevator to horizontal belt conveyor w/tripper mechanism conveyor	23 m bucket elevator to horizontal belt conveyor w/tripper mechanism	20 m bucket elevator to covered horizontal conveyor to center of warehouse onto horizontal track mount
Unloading equipment	100% skid-steer loader onto inclined belt conveyor	20% drawports: 80% skid-steer loader onto inclined belt conveyor	40% drawports onto inclined belt conveyor: 60% skid-steer loader into to dump pit, elevator and overhead bins	100% skid-steer loader onto inclined belt conveyor

[a] Peanuts from 1989 and 1990 crop were hauled 24 km to Goshen, AL. Peanuts from 1991 crop shipped 121 km to Graceville, FL.

Table 2. Dates loading was completed and unloading began at each warehouse in study to determine value loss of farmers stock peanuts during storage.

State	1989		1990		1991	
	Load	Bailout	Load	Bailout	Load	Bailout
Alabama	17 Oct 1989	03 Mar 1990	10 Oct 1990	24 Jan 1991	25 Oct 1991	28 Apr 1992
Georgia	18 Oct 1989	28 Feb 1990	17 Oct 1990	28 Jan 1991	17 Oct 1991	28 Mar 1992
North Carolina	15 Nov 1989	02 Feb 1990	30 Oct 1990	18 Feb 1991	25 Oct 1991	25 Feb 1992
Texas	18 Nov 1989	16 Feb 1990	03 Oct 1990	08 Apr 1991	30 Sep 1991	27 Jan 1992

accepted practice when necessary to control insect infestation.

When the peanut sheller was ready to unload the peanuts from the subject warehouse, an association representative removed the seals from the entrances. Peanuts were unloaded from the warehouse into trucks. Each truck was sampled by FSIS inspectors and an official grade was determined and recorded using a FV95. The loaded truck was weighed and the gross weight recorded by the buying point scale operator, the association representative, and the FSIS inspector. This portion of the data collection was referred to as "bailout".

Upon arrival at the shelling plant, the weight of the incoming truck was recorded. Using an approved pneumatic sampler, FSIS inspectors removed a sample large enough for the official grade sample and a 4.5-kg sample for evaluation of the shelling outturns at the National Peanut Research Laboratory's pilot shelling plant. The truck was unloaded according to the shelling plant's normal procedures. The tare weight was recorded by shelling plant personnel prior to the truck's departure. The trailer identification, seal numbers, FV95 data, and the gross and tare weights of the truck comprised the data collected at the commercial shelling plant, referred to as the "regrade" portion.

Daily composite samples of the TSMK, OK, and LSK were retained from the official grade samples during bailout and regrade. The moisture content of these daily composite samples was determined and recorded.

The 4.5-kg sample collected from each truck was identified with the FV95 serial number and a sequential number indicating when the truck arrived at the shelling plant. These samples were stored in a small storage building until all peanuts had been removed from the warehouse. After all peanuts had arrived at the shelling plant, the samples representing each load of peanuts in the subject warehouse were sent to the National Peanut Research Laboratory (NPRL) in Dawson, GA for shelling. The NPRL pilot shelling facility is equipped with shelling equipment used in commercial shelling facilities (4,6,7).

Upon arrival at the NPRL, the identity of the 4.5-kg samples was verified against the daily logs provided by FSIS personnel during bailout and regrade. The samples were placed in a hopper bin and weighed. The composite sample was emptied from the hopper bin into a dump pit similar to those used in a commercial shelling facility. Using a rotating spout sampler, a sample weighing 2.3 to 3.6 kg was removed to determine the moisture content of the kernels, hulls, LSK, and FM. A portion of that sample was hand-shelled and the hulls analyzed for oil content. The remainder of the composite sample was cleaned, shelled, and sized according to standard industry practices. Weights of FM, LSK, hulls, and kernels were recorded. Kernels were sized and sorted according to the standards set for each peanut market type in the Peanut Administrative Committee's Marketing Agreement.

All FV95 and ASCS-1007 forms were verified by FSIS and the area Peanut Grower Association. After verification, all FV95 and ASCS-1007 forms were sent to the Statistical Branch of USDA, AMS where the data were keypunched and error-checked. Additional error-checking and analysis were done at NPRL using PC-SAS version 6.04(9).

Results and Discussion

Mean grade factors were calculated using the gross weight of each load as a weighting factor. The 3-yr weighted means for each warehouse at load-in, bailout, and regrade are presented in Table 3. The 3-yr average

Table 3. Three-yr average (1989-1991) of farmers stock grade values at load-in, bailout, and regrade.

Grade factor	AL			GA			NC			TX		
	Load-in	Bailout	Regrade	Load-in	Bailout	Regrade	Load-in	Bailout	Regrade	Load-in	Bailout	Regrade
FM[a]	4.41	4.81	4.54	4.82	5.81	5.90	4.75	6.17	6.44	5.92	6.55	6.66
Moist. content (% wb)	8.80	6.77	6.91	9.14	7.16	7.22	8.18	6.14	6.30	7.84	6.65	6.28
LSK[a]	4.89	5.83	5.58	4.48	5.14	5.21	4.39	5.37	5.30	3.64	4.44	4.93
ELK[b]	NA	NA	NA	NA	NA	NA	44.11	39.99	40.14	NA	NA	NA
SMK[b]	70.61	68.35	67.57	70.86	69.20	68.53	67.07	63.75	64.79	61.49	59.29	58.88
SS[b]	3.02	4.34	5.31	2.52	3.46	4.28	3.14	5.21	4.57	4.08	6.20	6.47
TSMK[b]	73.63	72.69	72.88	73.38	72.66	72.81	70.21	68.96	69.37	65.57	65.49	65.35
OK[b]	4.98	5.40	5.65	4.24	4.81	4.74	1.97	2.29	2.06	6.13	5.97	6.03
DK[b]	0.50	0.49	0.70	0.40	0.64	0.56	0.53	0.80	1.01	0.56	0.74	0.65
TK[b]	79.11	78.58	79.23	78.02	78.11	78.11	72.71	72.05	72.43	72.25	72.21	72.04
Hulls[b]	20.81	21.36	20.70	21.81	21.79	21.79	27.31	28.21	27.60	27.76	27.80	27.96

[a]Foreign Material and Loose Shelled Kernels presented as percent of gross weight of all material in the warehouse.
[b]All kernel and hull grade factors are percent of peanut pods in the warehouse.

for each warehouse indicated that the average percent FM and LSK generally increased between load-in and bailout and between bailout and regrade. An equation presented by Slay (10) predicted the average percent LSK should increase approximately 1.2 percentage points due to physical damage during loading. The average observed increase in LSK of 0.8% from load-in to bailout. The LSK were most likely generated in the dump pits and elevators and due to the high impact force of the peanuts falling from the horizontal conveyor belt in the ridge of the warehouse. Similarly, Slay (10) presented an equation to estimate the change in FM due to impact forces. The estimated increase in FM due to impact was 1%. The FM had an average increase of 0.9%.

The average moisture content of 9% wb at load-in in Alabama and Georgia decreased to an average of about 7% wb at bailout, and remained approximately the same between bailout and regrade. The moisture content of the peanuts at load-in in North Carolina and Texas averaged about 8% wb during the 3-yr period. The moisture content at bailout was below the desired 7% wb in North Carolina and Texas, 6.1 and 6.6% wb, respectively.

The moisture content of the SMK of the daily composite samples was very close to the average moisture content observed in the official grades because the SMK comprise approximately 90% of all kernels present. The moisture content of the OK was higher than the SMK as expected. The smaller kernels are generally less mature than the SMK and thus have a higher moisture content. The LSK had the lowest moisture content of the three kernel categories. With no hull to buffer the kernel from the environment, the LSK reached equilibrium with ambient air more rapidly than those shelled during grading. This difference in moisture content indicated that most of the LSK were shelled during harvest rather than by the pneumatic sampler. The moisture content of LSK produced by the pneumatic sampler should be the same as inshell kernels.

Previous research by Slay (11) indicated that physical dimensions of peanut kernels decrease as moisture content decreases. Therefore, as the moisture content of the SMK decreases during storage, the resultant reduction in physical dimensions causes more peanuts to fall through the prescribed screen and be classified as OK.

Over the 3-yr period, the average percentage total kernels (TK) tended to increase slightly from load-in to bailout to regrade in warehouses storing runner peanuts. This result is probably due to the hulls losing moisture and weight loss due to abrasion during handling. Spanish-type peanuts stored in Texas had a negligible decrease in the TK from load-in to regrade while the TK of the virginia peanuts decreased 0.28%. The percent SMK decreased from load-in to bailout to regrade, but was at least partially offset by an increase in SS. This was because as the moisture content decreases the number of splits increases. In many cases, the TSMK (SMK + SS) also exhibited a decrease from load-in to bailout. In this case, the decrease in physical size of the whole and split kernels due to moisture loss caused more kernels to fall through the opening in the grade screen used to separate edible from inedible kernels. The percentage of damaged kernels increased from load-in to bailout and regrade. The decrease in SMK of spanish-type peanuts (Table 3) was almost completely offset by an increase in SS with virtually no change in the percentage OK and DK over the 3-yr period. The runner- and virginia-type peanuts experienced a decrease in SMK that was offset by increased percentages of SS, OK, and DK.

The component weights were calculated for each individual load of peanuts and summed over each stage of the study. In 1989 and 1990, the weight of total meats apparently increased from load-in to regrade in Alabama. According to the 1989 data, there were approximately 36.7 t of excess moisture at load-in. If this much moisture was lost, the gross weight of material at bailout should have been 1724.1 t. The actual weight of material after deducting the 2.7 t for excess moisture observed at bailout was 1726.8 t, approximately 2.7 t more than expected before accounting for moisture loss from the FM present, and represents approximately 0.2% of the material weight at bailout. A similar circumstance was observed in the 1990 Alabama data.

The weight of TSMK decreased each year for every warehouse except in the Alabama warehouse during the 1990 crop (Table 4), which apparently increased by 1.8 t; however, this is only an apparent increase due to reasons discussed previously. The weight of TSMK for the runner market-type peanuts (Alabama and Georgia) decreased an average of 2.19%. The TSMK weight of spanish- and virginia-type peanuts decreased an average of 2.81 and 3.94%, respectively. The average loss in weight of TSMK for all warehouses was 2.78%.

The weight of the components in conjunction with the unit value obtained from the ASCS Loan Schedules determined the total value of the load. The predominant factor in setting the loan value of the peanuts is the percentage TSMK in each load. The OK and LSK have a value of $154/t while the TSMK have a value of approximately $992/t. The total value of peanuts stored in each warehouse at load-in and regrade is shown in Table 5 for the 3-yr study period. For the purposes of this study, the dollar value of each load of peanuts was calculated using the 1990 Loan Schedules to eliminate the variation in value caused by the annual changes in the published Loan Schedules.

The total value of peanuts in each warehouse decreased from bailout to regrade with the exception of Alabama during 1989 and 1990 (Table 5). However, the

Table 4. Percentage change in the weight of total sound mature kernels in the warehouses from load-in to regrade during 1989, 1990 and 1991.

Warehouse	1989	1990	1991	3-yr avg
	%			
AL	-0.23	+0.54	-5.69	-1.79
GA	-3.13	-1.20	-3.48	-2.58
NC	-3.77	-2.89	-4.16	-3.94
TX	-3.53	-1.06	-3.85	-2.81

Table 5. Value of peanuts[a] and its change at load-in and regrade during the 3- yr shrink study at warehouses in Alabama, Georgia, North Carolina and Texas.

Stage	AL	GA	NC	TX
		1989		
Load-in	$1,179,412	$1,987,172	$1,255,910	$1,301,520
Regrade	$1,180,302	$1,926,816	$1,203,137	$1,256,254
Change	$890	$-60,356	$-52,773	$-45,266
% Change	0.08	-3.04	-4.20	-3.48
		1990		
Load-in	$361,789	$1,969,632	$1,365,772	$1,259,359
Regrade	$363,380	$1,949,239	$1,310,965	$1,243,502
Change	$1,591	$-20,393	$-54 807	$-15,857
% Change	0.44	-1.04	-4.01	-1.26
		1991		
Load-in	$1,302,873	$2,531,580	$ 1,541,221	$1,265,563
Regrade	$1,232,641	$2,448,204	$ 1 474 952	$1,218,949
Change	$-70,232	$-83,376	$-66,269	$-46,614
% Change	-5.39	-3.29	-4.30	-3.68
		3-yr avg		
% Change	-1.62	-2.46	-4.17	-2.81

[a]All peanut values calculated using the 1990 Peanut Loan Schedule to eliminate the year-to-year variation due to changes in the load schedule.

Table 6. Contribution of changes in grade factors between load-in and regrade to value change of farmers stock peanuts in all warehouses during the 3-yr shrink study.

State	Crop year	FM	LSK	Moisture loss	Kernel size distribution	Value change
				<7%		%
AL	1989	0.89	-0.16	0.00	- 0.65	0.08
	1990	0.57	-0.13	-0.12	0.12	0.44
	1991	-1.12	-1.02	-0.22	-3.03	-5.39
	Avg	0.11	-0.44	-0.11	-1.19	-1.62
GA	1989	-2.26	-0.33	0.00	-0.45	-3.04
	1990	-0.14	-0.88	0.00	-0.02	-1.04
	1991	-1.41	-0.12	0.00	-1.75	-3.29
	Avg	-1.27	-0.44	0.00	-0.74	-2.46
NC	1989	-2.38	-0.34	-0.51	-0.97	-4.20
	1990	-1.73	-0.71	-0.63	-0.94	-4.01
	1991	-2.49	-0.51	-0.37	-0.93	-4.30
	Avg	-2.20	-0.52	-0.50	-0.95	-4.17
TX	1989	-1.06	-1.33	-0.96	-0.12	-3.48
	1990	-0.16	-0.31	-0.07	-0.72	-1.26
	1991	-1.15	-1.10	-0.83	-0.60	-3.68
	Avg	-0.79	-0.91	-0.62	-0.48	-2.81

observed increase in value from load-in to regrade was so small that in all likelihood, no actual change in value occurred. The total value of runner peanuts in the Alabama and Georgia warehouses decreased an average of 1.62 and 2.46%, respectively, during the 3-yr study. This compared to a decrease in total weight of TSMK in the same warehouses of 1.79 and 2.58%, respectively. Similarly, the value of virginia-type peanuts decreased an average 4.17% compared to an average 3.94% reduction in weight of TSMK. The value of the spanish peanuts and the weight of TSMK were reduced an average of 2.81%. Percentage changes in the total weight of TSMK in a warehouse is a good indicator of the percentage change in the value of the peanuts.

Changes in various quality factors contributed to the change in peanut value. The primary causes for change in peanut value were change in the amount of FM and LSK, excessive moisture loss, and changes in the kernel size distribution (Table 6). The contribution of the changes in the individual grade factors toward the overall change in value was determined by first assuming that the grade factors were the same at regrade as they were upon load-in. Each grade factor was changed one at a time and a new value calculated. (Grade factors are not independent of each other and this procedure ignored this fact.) The change in value associated with the changed grade factor was determined as the percentage of the total change observed when the measured grade factors were used to calculate value. The contribution of each factor is presented so that the sum of the value change caused by each factor equals the total change in value.

Data for Alabama during 1989 and 1990 showed that the net weight was higher at regrade than at load-in due to minimal changes in the moisture content and foreign material. This increase in net weight was not offset by a decrease in kernel distribution; therefore, a higher dollar value was calculated at regrade than at load-in. The value loss for the Alabama peanuts during 1991, however, was the largest experienced for any warehouse during the entire study. The change in kernel size distribution accounted for more than half (56%) of the 5.39% loss in value.

The Georgia warehouse experienced an average of 2.46% loss in peanut value of which an increase in FM accounted for approximately 52% of the loss. The increase in LSK accounted for 16% of loss while change in kernel size distribution contributed 30%. Neither warehouse in the southeast had sufficient moisture loss to contribute significantly to loss in value.

The change in value of peanuts in the North Carolina warehouse was the most consistent throughout the 3-yr study (Table 5). The maximum loss in value of 4.30% occurred during 1991 while the minimum loss of 4.01% occurred during 1990. Contribution of each factor was fairly consistent throughout the 3-yr period, also. The largest cause of shrink in the North Carolina warehouse was the increase in FM (Table 6). This increase in FM was probably due to peanuts being shelled and dirt adhered to peanut pods being removed during handling. Observation during loading and unloading noted that excessive amounts of dirt were present in the peanuts each year. Significant amounts of dirt collected on the catwalk and on the belt conveyor frame during loading. As the peanuts dried out during storage, the dirt (which was already dry) became a higher percentage of the weight of the material in the warehouse.

The change in kernel size distribution contributed only slightly less than the FM. Moisture loss below 7% accounted for about the same value loss as did the increase in LSK. Excessive moisture loss decreases the weight of material that the buyer purchased. Increased LSK affects the value because these are peanuts that were purchased at approximately \$992/t compared to their value as LSK of \$154/t.

The combination of increased FM and LSK in the Texas warehouse accounted for approximately 60% of the 2.81% overall loss in value. Excessive moisture loss and change in kernel size distribution had roughly the same effect on the total loss in value.

Hull oil content analyses were made each year of the study for each composite sample shelled in the NPRL Pilot Shelling Plant. Before shelling the composite sample, three 500-g subsamples were removed for hand shelling. Approximately 100 g of hulls were obtained from each subsample and analyzed. Three 100-g samples of hulls were obtained from the hull material of each composite sample. The oil content of the hand-shelled hulls was compared to the oil content of the mechanically shelled hulls to determine if the aggressiveness of the mechanical sheller "bruised" the peanuts more than hand shelling. The 3-yr mean oil content of the hand-shelled virginia-type hulls was 0.89% while the corresponding mechanically shelled hulls had a 1.36% oil content. Hand-shelled runner peanuts had a hull oil content of 0.80 and 0.81% for Alabama and Georgia, respectively, while the mechanically shelled hulls had an oil content of 0.79 and 0.98%. Spanish peanuts had a hand-shelled hull oil content of 0.44% compared to 0.80% for the mechanically-shelled peanut hulls. Although these differences in oil content were statistically different, the meat content in the hulls required to cause the increase was not appreciable. It was generally less than 0.01% of the total peanut meat obtained from shelling the composite sample.

Shelling outturns estimated from the official farmers stock grades at load-in and regrade compared to the outturns obtained from the composite samples collected at regrade (Table 7) showed that the total kernels (TK) expected out of the shelling plant could be estimated within 1% by the farmers stock grade at load-in. However, the edible kernel outturn (TSMK) indicated by the grade at load-in was higher than the amount of edible kernels obtained from the pilot shelling facility. The edible kernel outturn estimated at regrade was lower than that obtained from the NPRL Pilot Shelling Plant because the grade assumes that all LSK are placed in oilstock. However, during the cleaning process prior to shelling, LSK are separated from the peanut pods, sized, and sorted. The whole, undamaged LSK riding the prescribed screen for edible peanuts were reclaimed and entered the edible stream of peanuts. Without exception, the whole kernels (SMK) obtained from the NPRL shelling facility were less than that indicated by either grade at load-in or regrade and, the split kernels were higher. This was especially true for the virginia peanuts. The shelling action of commercial shelling equipment is much more aggressive than the sheller used to grade the peanuts. The larger virginia peanuts are more susceptible to splitting because of their size as well as their lower moisture content at the time of shelling.

Under current marketing requirements, the sheller is obligated to verify that peanuts bought as additional peanuts are either exported or crushed for oil. The amount of peanuts that the sheller must export or crush is based upon the tonnage of SMK, SS, OS, and TK less a percentage of the original weight. Therefore, the outturns in each category are economically important to the sheller. Multiplying the shelling outturns (kg/t) shown in Table 7 by the net weight observed at the appropriate stage of the study, the TK outturns can be determined. The TK yields at load-in and from the shelling plant for each warehouse are shown in Tables 8 and 9. The outturns obtained from the NPRL Pilot Shelling Plant were applied to the mean net weight averaged for bailout and regrade. The SMK (whole edible kernels) outturns from the Alabama warehouse averaged 13.37% less than estimated from the original grade at load-in (Table 8). The individual reduction ranged from 9.13 to 16.95%. The SMK outturn from the Georgia warehouse averaged 11.86% less than indicated by the grade at load-in. The total SMK yield reduction from the Georgia warehouse ranged from 9.48 to 13.28%. However, the reduction in SMK for the runner peanuts was almost completely offset by the increase in splits. The split yield increased by 271 and 320% in the Alabama and Georgia samples, respectively, compared to the original estimate. This is primarily due to the differences between the shelling and conveying equipment used to determine the grade and in the shelling plant. Another factor contributing to the increased split outturns is the difference in moisture content at load-in and at bailout. Peanuts shelled at 7% wb will generally have a higher percentage of split kernels than peanuts shelled at the 9% wb observed at load-in regardless of the shelling equipment (3). This was noted in the SS percentage of the official grades at load-in and bailout. The total edible kernel outturn of the peanuts from Alabama decreased by 1.97% and by 1.26% in Georgia.

The 3-yr average reduction in total edible kernels was offset by a 12.7% increase in oilstock for peanuts obtained from the Alabama warehouse. The 3-yr average oilstock outturn observed in Georgia was 2.0% less than estimated by the load-in grade. A net reduction in TK of 1.3 and 0.2% observed in Georgia and Alabama, respectively.

Similar trends were observed for the virginia- and spanish-type peanuts as shown in Table 9. The observed whole edible kernel outturns of virginia-type peanuts (North Carolina) were 27.2% less than that estimated by the grade at load-in. Approximately 85% of the observed loss in whole edible kernels was offset by the 489% increase in split kernels. The increase in split kernels was higher for the virginia-type peanut than for the runner type due to both the lower moisture content at bailout (6% for virginia type compared to 7% for runners) and the higher susceptibility of virginia-type peanuts to splitting. The total edible kernel outturn averaged 3.80% less than indicated by the original grade and was consistent throughout the 3-yr study. The reduction in total edible kernel outturn ranged from 3.6 to 3.9% during the study.

Table 7. Comparison of the amount of peanut kernels (kg/net t) estimated from the official grades to the amount obtained from peanuts shelled in the NPRL pilot shelling plant.

Year	Kernel size	AL Load-in	AL Regrade	AL NPRL[a]	GA Load-in	GA Regrade	GA NPRL[a]	NC Load-in	NC Regrade	NC NPRL[a]	TX Load-in	TX Regrade	TX NPRL[a]
		kg/net t											
1989	SMK	693.95	669.45	625.65	671.25	655.30	595.05	628.65	591.75	443.30	580.70	542.10	492.95
	Splits	21.25	36.00	89.25	26.10	35.85	97.80	35.90	47.75	208.30	33.80	62.50	122.50
	TSMK	715.20	705.45	714.90	697.35	691.15	692.85	664.55	639.50	651.60	614.50	604.60	615.45
	OK	90.05	102.25	103.05	98.10	107.40	94.10	78.80	86.00	80.55	128.30	124.35	117.90
	TK	805.25	807.70	817.95	795.45	798.55	786.95	743.35	725.50	732.15	742.80	728.95	733.35
1990	SMK	648.90	625.05	556.90	674.15	641.90	588.60	638.40	614.30	535.90	598.35	572.20	562.45
	Splits	31.10	54.50	126.95	16.95	41.55	98.00	20.90	30.90	111.05	44.25	63.95	119.40
	TSMK	680.00	679.55	683.85	691.10	683.45	686.60	659.30	645.20	646.95	642.60	636.15	681.85
	OK	117.80	120.95	111.95	92.80	107.20	99.55	69.20	84.30	59.75	100.20	103.75	58.75
	TK	797.80	800.50	795.80	783.90	790.65	786.15	728.50	729.50	706.70	742.80	739.90	740.60
1991	SMK	665.90	614.60	560.80	677.95	644.85	614.35	651.15	613.40	438.75	592.80	558.95	541.65
	Splits	33.75	59.45	95.95	28.90	43.75	92.10	33.10	49.00	225.55	39.35	57.30	106.05
	TSMK	699.65	674.05	656.75	706.85	688.60	706.45	684.25	662.40	664.30	632.15	616.25	647.70
	OK	103.60	131.30	133.75	86.15	101.95	80.25	63.35	84.35	64.90	98.70	120.40	84.60
	TK	803.25	805.35	790.50	793.00	790.55	786.70	747.60	746.75	729.20	730.85	736.65	732.30
Avg	SMK	669.58	636.37	581.12	674.45	647.35	599.33	639.40	606.48	472.65	590.62	557.75	532.35
	Splits	28.70	49.98	104.05	23.98	40.38	95.97	29.97	42.55	181.63	39.13	61.25	115.98
	TSMK	698.28	686.35	685.17	698.43	687.73	695.30	669.37	649.03	654.28	629.75	619.00	648.33
	OK	103.82	118.17	116.25	92.35	105.52	91.30	70.45	84.88	68.40	109.07	116.17	87.08
	TK	802.10	804.52	801.42	790.78	793.25	786.60	739.82	733.92	722.68	738.82	735.17	735.42

[a] Shelling composite of 4.5-kg samples retained at regrade in NPRL Pilot Shelling Plant.

Table 8. Comparison of total shelling outturns estimated from official farmers stock grades at load-in and outturns obtained from composite samples obtained at regrade in Alabama and Georgia and shelled in the National Peanut Research Laboratory's Pilot Shelling Plant.

Kernel size	Stage	AL 1989	AL 1990	AL 1991	AL Avg	GA 1989	GA 1990	GA 1991	GA Avg
SMK	Load-in[a] (kg)	1,132,585	339,631	1,223,264		1,894,207	1,897,860	2,402,770	
	Shellout[b] (kg)	1,029,174	292,022	1,015,905		1,642,684	1,654,641	2,174,938	
	Difference (kg)	-103,411	-47,609	-207,359		-251,523	-243,219	-227,832	
	% Difference	-9.13	-14.02	-16.95	-13.37	-13.28	-12.82	-9.48	-11.86
SS	Load-in (kg)	34,676	16,273	62,007		73,630	47,789	102,421	
	Shellout (kg)	146,813	66,571	173,816		269,985	275,450	326,055	
	Difference (kg)	112,137	50,298	111,809		196,355	227,661	223,634	
	% Difference	323.39	309.09	180.32	270.93	266.68	476.39	218.35	320.47
TSMK	Load-in (kg)	1,167,261	355,904	1,285,271		1,967,837	1,945,649	2,505,191	
	Shellout (kg)	1,175,987	358,593	1,189,721		1,912,669	1,930,091	2,500,993	
	Difference (kg)	8,726	2,689	-95,550		-55,168	-15,558	-4,198	
	% Difference	0.75	0.76	-7.43	-1.97	-2.80	-0.80	-0.17	-1.26
OS	Load-in[c] (kg)	146,958	61,652	190,280		276,809	261,153	305,340	
	Shellout[d] (kg)	169,596	58,711	242,292		259,771	279,764	284,103	
	Difference (kg)	22,638	-2,941	52,012		-17,038	18,611	-21,237	
	% Difference	15.40	-4.77	27.33	12.65	-6.16	7.13	-6.96	-2.00
TK	Load-in (kg)	1,314,219	417,556	1,475,551		2,244,646	2,206,802	2,810,531	
	Shellout (kg)	1,345,583.00	417,304	1,432,013		2,172,440	2 209 855	2,785,096	
	Difference (kg)	31,364	-252	-43,538		-72,206	3,053	-25,435	
	% Difference	2.39	-0.06	-2.95	-0.21	-3.22	0.14	-0.90	-1.33

[a]SMK at load-in includes undamaged whole kernels riding a 6.35 x 19.05-mm slotted screen.
[b]SMK at shellout includes undamaged shelled kernels and LSK in the jumbo, medium, and No. 1 sizes.
[c]OS at load-in includes all LSK damaged kernels and kernels falling through a 6.35 x 19.05-mm slotted screen.
[d]Oil Stock at shellout includes all damaged kernels and LSK, split LSK, and all whole, undamaged kernels, and LSK falling through a 6.35 x 19.05-mm slotted screen.

Table 9. Comparison of shelling outturns estimated from official farmers stock grades at load-in and outturns obtained from composite samples obtained at regrade in North Carolina and Texas and shelled in the National Peanut Research Laboratory's Pilot Shelling Plant.

		NC				TX			
Kernel size	Stage	1989	1990	1991	Avg	1989	1990	1991	Avg
SMK	Load-in[a] (kg)	1,129,976	1,262,341	1,395,337		1,215,380	1,168,426	1,177,577	
	Shellout[b] (kg)	780,681	1,041,217	930,706		1,015,478	1,091,213	1,064,002	
	Difference (kg)	-349,295	-221,124	-464,631		-199 902	-77,213	-113,575	
	% Difference	-30.91	-17.52	-33.30	-27.24	-16.45	-6.61	-9.64	-10.90
SS	Load-in (kg)	64,558	41,285	70,898		70,720	86,407	78,207	
	Shellout (kg)	366,830	215,757	478,452		252,324	231,652	208,321	
	Difference (kg)	302,272	174,472	407,554		181,604	145,245	130,114	
	% Difference	468.22	422.60	574.85	488.56	256.79	168.09	166.37	197.08
TSMK	Load-in (kg)	1,194,534	1,303,626	1,466,235		1,286,100	1,254,833	1,255,784	
	Shellout (kg)	1,147,511	1,256,974	1,409,158		1,267,802	1,322,865	1,272,323	
	Difference (kg)	-47,023	-46,652	-57,077		-18,298	68,032	16,539	
	% Difference	-3.94	-3.58	-3.89	-3.80	-1.42	5.42	1.32	1.77
OS	Load-in[c] (kg)	141,636	136,870	135,759		232,805	195,721	196,098	
	Shellout[d] (kg)	141,854	116,121	137,670		242,953	113,978	166,86	
	Difference (kg)	218	-20,749	1,911		10,148	-81,743	-29,912	
	% Difference	0.15	-15.16	1.41	-4.53	4.36	-41.77	-15.25	-17.55
TK	Load-in (kg)	1,336,170	1,440,496	1,601,994		1,518,905	1,450,554	1,451,882	
	Shellout (kg)	1,289,365	1,373,095	1,546,828		1,510,755	1,436,843	1,438,509	
	Difference (kg)	-46,805	-67,401	-55,166		-8,150	-13,711	-13,373	
	% Difference	-3.50	-4.68	-3.44	-3.87	-0.54	-0.95	-0.92	-0.80

[a]SMK at load-in includes undamaged whole kernels riding appropriate slotted screen for virginia-and spanish-type peanuts
[b]SMK at shellout includes undamaged shelled kernels and LSK in the ELK or jumbo medium (virginia type only) and No. 1 sizes.
[c]OS at load-in includes all LSK damaged kernels and kernels falling through appropriate slotted screen.
[d]OS at shellout includes all damaged kernels, split LSK, and kernels and LSK falling through appropriate sized screen.

The oilstock outturns also averaged 4.5% less than expected. However, it ranged from a 15.2% loss to a 1.4% increase. The total kernel outturn observed for the virginia peanuts averaged 3.9% less than estimated from the load-in grade and ranged from 3.4 to 4.7%.

The SMK outturn observed in the spanish-type peanuts (Texas, Table 9) averaged 10.9% less than estimated from the official grade at load-in. During the 3-yr study, the difference ranged from 6.61 to 16.45% less than grade estimates. Split outturns were approximately twice that of the load-in grade. In 1990 and 1991, the increase in split kernels more than offset the decrease in whole edible kernels. Oilstock outturns were 41.8 and 15.3% less than estimated from official grades during 1990 and 1991, respectively. Yet, the TK outturn decreased by approximately 0.9% in 1990 and 1991. This indicated that some of the smaller kernels when split were shaped such that they did not fall through the screen used to separate splits from oilstock. The TK outturns for spanish peanuts averaged 0.8% less than estimated from the load-in grade.

Analysis of actual shelling outturns indicated that the TK yield was 0.2 to 3.9% less than expected outturns based upon the grades at the time of purchase. This agrees with current regulations for contract additional peanuts requiring that TK weight less 4% must be exported or crushed for oil. However, the data showed that the whole edible kernel runner and spanish outturns were approximately 11% less than estimated from the load-in grade and the virginia whole edible kernel outturns were approximately 27% less than load-in estimates. The total edible kernel outturns for runner-type peanuts averaged 1.6% less than expected; the spanish-type peanuts averaged 0.8% less than estimated; virginia-type edible outturns were 3.9% less than expected. The data clearly showed that the difference between actual outturns and that expected based from the grade was not consistent throughout all kernel size categories. The data also showed that total edible kernels (TSMK) was reduced by approximately the same percentage as the total kernel content.

Summary

A project to determine the amount of value loss occurring in peanuts during long-term bulk storage was completed at the request of USDA-ASCS and with the cooperation of three shellers, four buying points, USDA-AMS, and the FSIS. The loss in loan value was found to average approximately 2.5% for runner peanuts, 2.8% for spanish peanuts, and 4.2% for virginia peanuts. The change in weight of the TSMK kernels from load-in to regrade was found to be a suitable indicator of value change and may be easier to keep records of than having to generate the ASCS-1007 form to determine value both at load-in and regrade. Analysis of the TK yield from warehouses storing runner-type peanuts had an average 0.77% loss compared to the TK yield estimated from the load-in grades. The virginia peanuts had a 3-yr average loss in TK yield of 3.9%. A loss of 0.8% was experienced in the spanish peanuts. It was also noted that, these

losses were not uniform for all kernel sizes. The yield of whole edible kernels decreased while the split kernels and oilstock usually increased. The data verified that satisfying an obligation for whole edible kernels would be more difficult than satisfying obligations for splits or oilstock. If the obligation was based on edible kernels, i.e. wholes and splits combined, the yield reduction would be more in line with that observed for the TK yield.

Acknowledgments

Successful completion of the 3-yr shrink study required a lot of hard work and effort from a large number of people from various segments of the peanut industry. We extend our sincere thanks and appreciation to all that participated in the study. It would be impossible to name them all, but we would like to recognize some key individuals from the various areas. From the Virginia-Carolina area, Brack Griffin, Gray Taylor, and their staff, Edgecombe-Pitt Cooperative, Conetoe, NC; Graham O'Berry, Ed Horsley, and their staff, Golden Peanut Company, Ahoskie and Aulander, NC, respectively; Robert Martin, Kenneth Perry, and their staff, FSIS, Williamston, NC; and Thomas Cotton, Steve Carroll, and their staff, PGCMA, Franklin, VA. Those from the southwest area include Milton Smith and staff, Golden Peanut Company, DeLeon, TX; Daymond Power and staff, Golden Peanut Company, Comyn, TX; Jimmy Williams and Kenneth Whitley and their staffs, FSIS, Harlingen and Gorman, TX, respectively; and Ross Wilson and Lester Seaton, and their staff, SWPGA, Gorman, TX. Those from the southeast area include Jimmy Curry, Curry Farm Supply, Shellman, GA and his staff; Jerry Chandler, McCleskey Mills, Smithville, GA and his staff; Ron Wood and Jimmy Griffin, FSIS, Albany, GA and their staff; Charles Coker and Luther Barrs, GFA Peanut Association, Camilla, GA and their staff; Frank Talbot and Mickey Hughes, Andersons Peanuts, Troy and Goshen, AL, respectively and their staffs; Robert Spann and Jerry Adkins, FSIS, Dothan, AL and their staff; Kenneth Blount, Golden Peanut Company, Graceville, FL and his staff; and Lamar Reddish, FSIS, Graceville, FL and his staff. Also to Larry Lace, AMS, Washington, DC and his staff with special thanks to the Statistical Branch, including Jeremy Wu, Mike Hogye, and Scott Binde for compiling the data for analyses; Wilda Martinez, ARS, Beltsville, MD; and Dallas Smith, ASCS, Washington, DC and his staff including Solomon Whitfield, David Kincannon, and Gary Fountain.

The following NPRL staff were crucial in the collection, transportation and evaluation of samples collected during this study: C. T. Bennett, J. L. Powell, and the late W. G. Ferguson.

Literature Cited

1. Anonymous. 1990. Shrinkage issue between shellers and growers. The Albany Herald, January 31.
2. Beasley, E. D., and J. W. Dickens. 1963. Engineering research in peanut curing. North Carolina Agric. Exp. Stn. Tech. Bull. No. 155.
3. Davidson, J. I., Jr., P. D. Blankenship, and R. S. Hutchison. 1970. Shelling and storage of partially dried (cured) peanuts. J. Amer. Peanut Res. Educ. Assoc. 2:57-64.
4. Davidson, J. I., Jr., R. S. Hutchinson, and F. P. McIntosh. 1976. Some performance characteristics of the standard cast-iron peanut sheller. USDA, ARS, ARS-5-129. U.S. Govt. Print. Ofc., Washington, DC.
5. Diener, U. L., R. E. Pettit, and R. J. Cole. 1982. Aflatoxins and other mycotoxins in peanuts, pp. 486-519. *In* H. E. Pattee and C. T. Young (eds.) Peanut Science and Technology. Amer. Peanut Res. Educ. Soc., Yoakum, TX.
6. McIntosh, F. P., J. I. Davidson, Jr., and R. S. Hutchison. 1971. Some methods of determining milling quality of farmers' stock peanuts. J. Amer. Peanut Res. Educ. Assoc. 3:43-51.
7. Payne, J. A., L. M. Redlinger, and J. I. Davidson, Jr. 1970. Shelling plant studies with insect-infested peanuts. J. Amer. Peanut Res. Educ. Assoc. 2:103-108.
8. Powell, J. T. 1990. The realism of shrinkage. Southeastern Peanut Farmer 28(1):3-4.
9. SAS Institute. 1985. Procedures Guide for Personal Computers. SAS Institute, Inc., Cary, NC.
10. Slay, W. O. 1976. Damage to peanuts from free fall impact. USDA, ARS, ARS-2-123. U.S. Govt. Print. Ofc., Washington, DC.
11. Slay, W. O. 1976. Dimensional changes in peanut pods, kernels and hulls as moisture is removed during drying. USDA, ARS, ARS-S-81. U.S. Govt. Print. Ofc., Washington, DC.
12. Smith, J. S., Jr. and J. I. Davidson, Jr. 1982. Psychometrics and kernel moisture content as related to peanut storage. Trans. ASAE 25:231-236.

Accepted 20 January 1995