Unloading Farmers' Stock Warehouses with a Peanut Vacuum

C. L. Butts*, R. B. Sorensen, and M. C. Lamb[1]

ABSTRACT

A peanut vacuum developed by redesigning an existing grain vacuum (vac) specifically to handle farmers' stock peanuts was tested. The peanut vac consists of a PTO-driven positive displacement blower, two cyclone separators, and a hydraulically-powered airlock valve. The blower pulls air and farmers' stock peanuts through a length of suction hose into the first cyclone separator where the peanuts are separated from the airstream. The air then travels to a second cyclone separator where the suspended dirt and other fine particles are separated from the airstream. The cleaned air proceeds through the blower and is blown through a discharge chute beneath the outlet of an airlock valve mounted on the bottom of the first cyclone. Farmers' stock peanuts from the first cyclone fall from the outlet of the airlock valve into the airstream in the discharge chute and are conveyed up into a waiting trailer. The peanut vac is powered by a 1000-rpm PTO shaft of a tractor supplying a minimum of 75 kW. Initial feasibility tests were conducted while unloading 1/10-scale farmers' stock warehouses to determine the optimum operating parameters to minimize mechanical damage. The optimized peanut vac was taken to two locations in South Georgia and used to extract peanuts from farmers' stock warehouses in addition to the conventional equipment used for warehouse bailout. The weight of peanuts on each truck, time to fill each truck, and the farmers' stock grade factors for the peanuts in each truck was recorded and compared by conveyance method. At the first location, the conventional equipment consisted of a skid-steer loader with an oversized bucket driven into the pile of peanuts. The peanuts were emptied into a surge bin feeding a portable conveyor belt that conveyed the peanuts into a waiting truck. At the second location, a large articulated bucket loader was used in lieu of the skid-steer loader. Peanuts loaded using the conventional method averaged 5.2% foreign material (FM) and 6.7% loose shelled kernels (LSK). Peanuts loaded using the peanut vac averaged 2.7 and 4.9% FM and LSK, respectively. Trucks were loaded at a rate of 187 MT/h using conventional equipment compared to 61MT/h using the peanut vac.

Key Words: Conveyor, farmers' stock peanuts, handling, pneumatic, warehouse.

The USDA defines farmers' stock peanuts as peanuts that have been threshed but have not been shelled, crushed, cleaned or otherwise changed from the form in which customarily marketed by producers (USDA 2017). Farmers typically deliver farmers' stock peanuts to a nearby central peanut buying point where they are dried, graded, cleaned and then placed in bulk storage structures.

The storage structures, aka farmers' stock warehouses, take many shapes and sizes, but most are steel frame buildings with sheet metal siding and roofing (Davidson *et al.* 1982). A typical farmers' stock warehouse is 24.3 m (80 ft) wide, 7.3 m (24 ft) high at the eave and varies in length from 55 m (183 ft) to 122 m (400 ft) depending on the desired storage capacity. These warehouses can store from 5300 to 10,000 MT of farmers' stock peanuts. Farmers' stock peanuts are emptied into a dump pit where a bucket elevator then lifts the peanuts to a conveyor belt located in the ridge that extends the full length of the warehouse (Fig 1). The conveyor belt is equipped with a tripper to divert the peanuts and discharge them to the side. The tripper can be moved the entire length of the belt allowing the operator to layer the peanuts into the warehouse until it is filled (Davidson *et al.* 1982).

When a warehouse is opened and unloading begins, a portable conveyor is placed beneath a drawport in the door's bulkhead. The slide gate is opened allowing peanuts to flow onto a conveyor belt and into a waiting truck (Fig 2). Once peanuts stop flowing out of the drawport, the bulkhead is removed, and a bucket loader is used to pick up the peanuts and load them onto the conveyor (Fig 3). Large front-end loaders and smaller skid-steer loaders are driven into the peanut pile to fill the large over-sized bucket. Peanuts can be crushed or otherwise mechanically damaged during this unloading process, increasing the amount of foreign material (FM) and loose shelled kernels (LSK).

In a 3-yr study, the value of runner type peanuts decreased an average of 2.0% (Butts and Smith 1995). Increased FM and loose shelled kernels LSK accounted for approximately 45% of the change in value. The decreased value due to increased FM and LSK results from in-shell peanuts being shelled

[1]Authors: Research Agricultural Engineer, Research Agronomist, and Supervisory Food Technologist, USDA, ARS, National Peanut Research Laboratory, Dawson, GA.

*Corresponding author's E-mail: chris.butts@ars.usda.gov

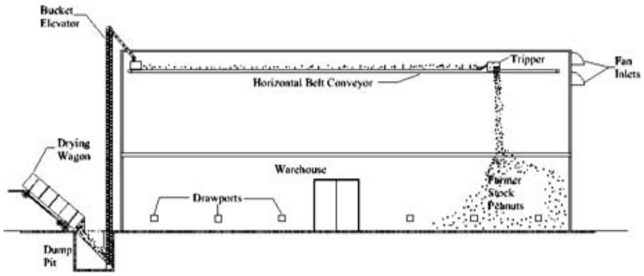

Fig. 1. Schematic of a typical farmers' stock warehouse.

during the handling. In-shell peanuts are purchased at a price of approximately \$0.39/kg. When peanuts are shelled during handling prior to arrival at the shelling plant, those peanuts have a value of approximately \$0.12/kg. The specific cause of increased FM and LSK was not determined in this study, however, impact of peanuts falling from the overhead conveyor into the warehouse and unloading the warehouse could have both caused significant increases of FM and LSK.

Blankenship and Lamb (1996) compared the mechanical damage to peanuts using conventional loading and unloading equipment to using potato handling equipment. The potato handling equipment basically consists of several sections of belt conveyor with the final section being able to elevate and steer to place the product where necessary. A flat conveyor section that lies on the floor beneath the truck hopper was used to empty the truck and load the warehouse. When unloading the warehouse, a steerable scoop drives to the edge of the pile and the belt extends into the pile (Fig 4). Peanuts flow onto the belt and into the waiting truck. Their analysis showed that the potato handling equipment reduced LSK by 1.8% and sound splits by 4% compared to a conventional bucket loader. When using the potato handling equipment to load a warehouse, the depth of the pile is limited by the vertical reach of the conveyor and is usually no more than 7 m.

Fig. 3. Skid-steer loader emptying farmers' stock peanuts into bin for transfer onto a waiting truck for transport to the shelling plant.

Since the work by Blankenship and Lamb (1996), the use of flat storage structures has increased. These structures are characterized by building widths up to 61 m (200 ft) and lengths up to 122 m (400 ft). Eave height on these buildings is usually 4.5 to 7 m. Peanut depths are usually 7 m or less with little or no peanuts on the walls of the building. Another characteristic of these flat storage facilities is that structural columns throughout the interior space supporting the roof impede the maneuverability of the bucket loaders to move peanuts in and out of the facility. The potato handling equipment is well-suited for this type of flat storage structures.

Pneumatic conveying systems are used frequently in commercial grain handling facilities, barges, and on-farm storage (Loewer *et al.* 1994). Pneumatic conveying systems are of three general types. In a positive pressure (push) conveying system, air is forced through a pipe by a blower and the grain

Fig. 2. Peanuts flowing from the drawport of a farmers' stock warehouse.

Fig. 4. Potato handling equipment used to unload farmers' stock peanuts from flat storage.

Fig. 5. Manually unloading farmers' stock peanuts from the 1/10-scale warehouses.

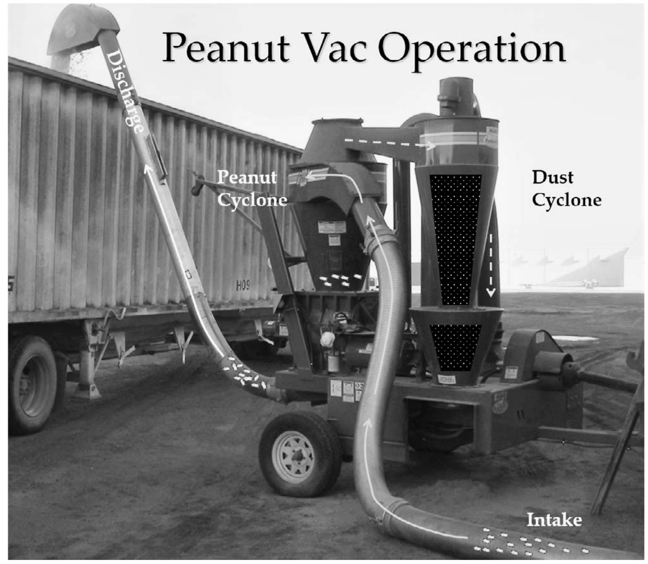

Fig. 6. Annotated photograph of a PTO-driven peanut vac showing flow of peanuts into the intake pipe, into the cyclone separator, through the airlock valve and into the discharge airstream.

falls from a holding tank through an airlock into a flowing airstream and conveyed to its destination. In a negative pressure, or pull-type, conveying system both the air and grain are pulled toward the intake of a fan/blower into a cyclone to separate the grain before it flows through the blower. The third type is a combination unit where grain is picked up and conveyed to the cyclone where it is dropped out and back into the flowing air stream from the same blower. Pneumatic systems are used in farmers' stock cleaning systems and the shelling plant to aspirate and convey light trash, dirt, and hulls from the shelling process (Davidson *et al.* 1982). Portable grain vacuums have been used on farmers' stock peanuts only in very limited situations such as final clean-up of a warehouse or spillage following an overturned trailer.

There are no published data on conveying capacities or mechanical damage to farmers' stock peanuts when using a pneumatic conveying system. The objective of this study was to evaluate the conveying capacity of a peanut vac and the mechanical damage caused by pneumatic conveyance of farmers' stock peanuts.

Materials and Methods

Initial Feasibility Tests. Approximately 4 MT of farmers' stock peanuts from the 2014 peanut crop were stored in each four 1/10-scale farmers' stock warehouses (Butts *et al.* 2006). Peanuts were unloaded from the four warehouses on 5 May 2016. Approximately one-half the peanuts were unloaded from each warehouse by manually scooping peanuts with a 19-L bucket from the warehouse and pouring them into a pallet bin conveyor belt then transferred into a peanut drying trailer (Fig 5). The remaining peanuts in each warehouse were unloaded using one of two prototype peanut vacs (Model 6614 or Model 7816, Walinga, Fergus, ON/Canada). The peanut vac was a PTO-driven combination type pneumatic conveying system (Fig 6). Air and peanuts were drawn into a 15-cm intake tube and conveyed into a cyclone separator equipped with a hydraulically-driven airlock valve. The peanuts drop out of the airstream in the cyclone separator. The air continues into a second cyclone separator to remove any remaining dust and into the intake of the PTO-driven positive displacement blower. The blower discharges the clean air through a muffler and into the discharge duct. An airlock valve at the bottom of the first cyclone rotates and allows the peanuts to fall into the discharge air stream and are conveyed into a waiting trailer. Four 2-kg samples were collected manually from each warehouse as it was unloaded and prior to the peanuts entering the peanut vac intake. An additional four 2-kg samples were collected from each warehouse as peanuts were discharged from the peanut vac into the trailer. The time to fill the trailer with the peanut vac was recorded. The tare and gross weights of each of the four trailers was recorded. Farmers' stock grade factors were determined by Alabama Federal-State Inspection Service. Grade factors from before and after transfer by the peanut vac were compared using analysis of variance.

Commercial Tests. Based on initial feasibility tests, the Model 7816 was chosen and modified for the commercial tests. The peanut vac manufacturer increased the diameter of the inlet pipe from 15 to

Table 1. Logistics of unloading the peanuts from warehouses for the initial feasibility of using a peanut vac for handling farmers' stock peanuts.

Warehouse	Unloading Method[a]	Unload Time (min)	Peanut weight (kg)	Load-out rate (MT/hr)
1	7816	5.19	2382	27.52
	Manual		1364	
2	7816	5.03	2255	26.91
	Manual		1391	
3	7816	DNR[b]	1891	
	Manual		1455	
4	6614	6.05	2009	19.92
	Manual		1746	

[a]7816 = Walinga Model 7816; 6614 = Walinga Model 6614; Manual = hand loaded
[b]Abbreviations Data not recorded, DNR

18 cm, the diameter of the airlock valve to 56 cm, and the capacity of the positive displacement blower, and modified the shape and configuration of the exit of the discharge into the trailer. The commercial prototype peanut vac (Model 7816DLX Peanut-Vac, Walinga, Fergus, ON/Canada) and a 107kW tractor (Model 6125R, John Deere, Moline, IL/USA) was transported and used at two commercial peanut warehouses. At each warehouse, hopper-bottom trucks typically used to haul farmers' stock peanuts were loaded using a bucket loader and conveyor belt or the peanut vac. At the warehouse located in Ashburn, GA a skid-steer loader (Model 262C, Caterpillar, Peoria, IL or similar) with a bucket capacity of approximately 0.5 MT was used to load trucks. An articulated front-end loader (Model 644K, John Deere, Moline, IL or similar) with a bucket capacity of approximately 1 MT was used at the warehouse located in Colquitt, GA. Both warehouses were on the same premises as the shelling plant. The time required to fill a truck was recorded for at least three trucks for each loading method at each location. Once the truck was filled, it proceeded to the scales where the gross weight was recorded. The truck was then sampled according to Federal-State Inspection protocol using the pneumatic sampler three times. Each sample was evaluated according to farmers' stock inspection guidelines (USDA 2017). At least eight trucks were graded for each method of loading. Grade data and loading times were analysed using analysis of variance for means separation.

Results and Discussion

Initial Feasibility Tests. The loading rate using the peanut vacs ranged from 19.9 to 27.5 MT/h (Table 1) during the feasibility tests. While using the Model 6614 peanut vac, a considerable and unacceptable number of peanut hulls were observed in the peanuts discharged into peanut wagon. The apparent high volume of peanut hulls would normally indicate a high percentage of LSK being generated during the transfer process. Therefore, a decision was made to use the Model 7816 peanut vac on the three remaining warehouses. While no statistical inferences can be made regarding the load-out rate, the Model 7816 transferred peanuts at an average rate of 27.2 MT/hr. Peanuts were transferred at a rate of 19.9 MT/hr using the Model 6614 peanut vac.

Analysis of variance with grade factors and loan value parameters as the dependent variables was performed using warehouse, unload method, and repetition as the main effects. The analysis indicated that the data for warehouses 1, 2, and 3 (unloaded with the Model 7816) should be analysed separately from warehouse 4 which was unloaded using the Model 6614 peanut vac. (Table 2). When unloading with the Model 6614 peanut vac, the LSK, sound mature kernels (SMK), and sound splits (SS) were significantly different than those transferred manually. The peanut vac increased LSK by approximately 5% compared to those manually transferred to the peanut wagon. It was also noted that SMK were approximately 3% lower and the SS were approximately 4% higher in the peanuts transferred pneumatically. There was no significant difference in the total SMK (TSMK = SMK + SS). However, when used to determine the farmers' stock loan value prior to deductions, the peanuts transferred using the Model 6614 were $16 lower in value than the peanuts transferred manually. This difference in value increased to about $19/MT when deducts for excessive FM and SS were included.

In the remaining three warehouses unloaded using the Model 7816 peanut vac, similar differences in grade and value were observed, but not to the same degree. LSK were 1.6% higher in the pneumatically loaded peanuts compared to those

Table 2. Grade factors and farmers' stock loan value of peanuts unloaded from 1/10-scale warehouses manually and using peanut vacs.

	Model 6614[a]			Model 7816[b]		
Grade factor	Manual	Pneumatic	Prob > F	Manual	Pneumatic	Prob > F
Foreign Material (%)	7.9	7.1	0.1065	3.6	4.2	0.2088
Loose Shelled Kernels (%)	6.5	11.6	0.0007	6.1	7.7	<0.0001
Sound Mature Kernels (%)	60.2	56.9	0.0498	62.9	62.4	0.7457
Sound Splits (%)	11.7	15.6	0.0107	9.4	10.8	0.2792
Total Sound Mature Kernels (%)	71.8	72.5	0.1867	72.3	73.3	0.0246
Other Kernels (%)	4.9	4.3	0.1447	4.4	3.7	0.0129
Damaged Kernels (%)	0.2	0.3	0.5159	0.2	0.3	0.3839
Hulls (%)	22.9	22.8	0.7345	22.8	22.3	0.0036
Loan Value ($/MT)	298.69	282.02	0.0370	322.23	308.20	0.6469
Excess FM Deduct ($/MT)	3.86	3.08	0.1201	0.47	0.28	0.4840
Excess Splits Deduct ($/MT)	6.12	9.29	0.0102	4.33	5.47	0.2780
Net Value ($/MT)	288.71	269.65	0.0305	306.43	302.45	0.6107

[a]n=4 samples for each unloading method
[b]n=12 samples for each unloading method

manually transferred. This indicated that the larger airlock valve among other design differences between the two conveyors was beneficial in reducing the mechanical damage and provided insight to the manufacturer for modifications needed for the commercial prototype.

Commercial Tests. Tests at commercial farmers' stock warehouses were conducted in Dec 2016 and Jan 2017. At the first warehouse, the co-operator's conventional method for unloading the warehouse utilized the skid-steer loader. Unloading had been underway for at least a day and the bulkhead was removed and the skid-steer loader was operating inside the farmers' stock warehouse. The peanut vac was set up on the other end of the warehouse so that both unloading methods could be used simultaneously. The drawport in the bulkhead was opened and the peanut vac intake hose inserted into the open drawport (Fig. 7). Peanuts continuously flowed into the intake.

There was no significant difference ($\alpha = 0.05$) in the percent FM or LSK that could be attributed to the method of loading the truck when comparing the conventional skid-steer loader to the peanut vac (Table 3). The moisture content of the peanuts loaded by the skid-steer loader was 0.7% drier than those loaded using the peanut vac and that is most likely due to location in the warehouse. The skid-steer was loading peanuts from well within the interior and the peanuts being loaded by the peanut vac were from near the exterior wall during these tests. There was no difference in the sound mature kernels (SMK) due to the loading method, but the peanuts loaded with the peanut vac had 2.8% higher split kernels. The other official grade factors for runner peanuts were not significantly different. However, the percent cracked and broken peanut pods is an important factor for virginia type peanuts that are roasted and sold in-shell. Approximately 29% of the peanuts transferred using the pneumatic conveyor were cracked and broken compared to 16% of the peanuts loaded using the skid-steer loader.

Fig. 7. Peanut vac in use to unload farmers' stock peanuts from the warehouse into the truck during testing to compare capacity and mechanical damage with conventional warehouse unloading systems.

The skid-steer loader was able to load farmers' stock peanuts at an average rate of 121 MT/h compared to 75 MT/hr using the peanut vac. This is equivalent to the skid-steer loading 21 MT into a truck once every 10.5 min compared to it taking 17 min to load the truck with the pneumatic conveyor.

At the second location, an articulated front-end loader was used to load trucks. Again, the equipment was positioned so that both the bucket loader and the peanut vac could be used simultaneously. Trucks loaded by the articulated bucket loader had more FM (5.3%) and LSK (7.5%) than those loaded with the peanut vac (2.4 and 4.3%, respectively). The moisture content of the peanuts was similar because both loaders were extracting peanuts from the interior of the warehouse. The

Table 3. Grade factors and load out rate using a peanut vacuum[a] to unload peanuts from a farmers' stock warehouse compared to using skid-steer and articulated bucket loaders.

Grade factor	Skid-Steer	Peanut Vac	Prob > F	Articulated	Peanut Vac	Prob > F
Foreign Material (%)	5.0	3.1	0.1772	5.3	2.4	<0.0001
Loose Shelled Kernels (%)	5.4	5.8	0.7510	7.5	4.3	0.0016
Moisture Content (%)	6.4	7.1	<0.0001	6.4	6.5	0.5112
Sound Mature Kernels (%)	68.4	67.4	0.3695	63.1	66.1	0.0115
Sound Splits (%)	5.4	8.2	0.0473	10.6	9.3	0.2250
Total Sound Mature Kernels (%)	73.8	75.6	0.0625	73.7	75.3	0.0315
Other Kernels (%)	3.0	2.5	0.2941	3.6	2.9	0.2213
Damaged Kernels (%)	0.62	0.69	0.7208	0.88	0.84	0.8096
Hulls (%)	22.4	20.9	0.0992	21.6	20.8	0.1730
Cracked/Broken (%)	16.3	29.5	0.0644		Not Measured	
Load-out Rate (MT/hr)	121.0	74.8	0.0031	235.9	51.5	<0.0001
Load-out Time (min/truck[b])	10.5	17.0	0.0048	5.3	24.9	<0.0001
Trucks per 8-hr day	46	29	0.0032	89	19	<0.0001

[a]Abbreviation: vacuum, vac

[b]Average net peanut weight per truck = 21 MT

percent SMK was slightly higher, 66% compared to 63%, for peanuts loaded using the peanut vac. Splits were numerically higher, but not significantly different, in the trucks loaded using the front-end loader. The TSMK was only slightly higher (1.6%) in the trucks loaded using the peanut vac. The differences in SMK, SS, and TSMK could have been due to the spatial variability of the peanuts within the warehouse. The percent cracked and broken pods was not measured at the second warehouse due to miscommunication.

The time required to load a truck using the peanut vac was considerably longer than that required when using the articulated front-end loader. The front-loader could load 21MT on a truck in about 5 min. The peanut vac required an average of 25 minutes. The pneumatic loader was slower at the second location (51.5 MT/hr) than at the first location (75 MT/hr). At the first location, the loading rate was limited primarily by the rate at which the peanut vac could convey the peanuts away from the pile as they flowed toward the drawport gate. In the second warehouse, the intake hose was inside the warehouse near the floor and the flowrate was limited primarily by the rate at which the peanuts would flow down the pile to the vac intake. The intake hose was continuously having to be repositioned to maintain maximum flow.

If the data for both types of bucket loaders are combined as conventional methods for unloading farmers' stock warehouses, then general performance of the peanut vac can be compared to the conventional method (Table 4). Only those performance factors whose means are significantly different due to load-out method are shown. On average, the trucks loaded using the peanut vac tended to have lower FM and LSK. Indicating that a significant portion of material being loaded using conventional methods may be getting crushed. The pneumatic conveyor is removing some additional dirt and other material through the high air velocity in the first cyclone and then dropping it out in the second cyclone.

The performance data show that conventional methods of loading out the warehouse can average approximately 187 MT/hr filling a truck about once every 8 min compared to the peanut vac loading a truck every 22 min. If a 25-MT/hr shelling plant is being supplied from a single warehouse, conventional unloading equipment may be necessary to make sure that loading trucks during an 8-hr workday can supply the shelling plant for a full 24-h shift. If the same shelling plant is being supplied from two or more farmers' stock warehouses, then the peanut vacs could adequately maintain the required plant feed rate.

The peanut vac requires approximately 60kW (85 hp) supplied to the PTO to operate properly and therefore must be accompanied by an appropriate sized tractor or have a dedicated power unit. If a dedicated power unit were used, then small vehicles could be used to tow the peanut vac and a trailer with the associated intake piping. The time to set up the peanut vac is less than 30 min and unloading could begin within 30 min of initial arrival. Conventional unloading equipment requires at least two vehicles as well, one to tow the belt conveyor and a second with a trailer capable of hauling either the skid-steer or the larger front-end loader. The latter may require a commercial driver license (CDL). The bin which accepts the peanuts from the loader and empties onto the conveyor belt may also have to be transported from warehouse to

Table 4. Comparison of grade factors and load-out performance using conventional farmers' stock warehouse unloading equipment and pneumatic conveyors.

Grade factor	Conventional	Peanut vac[a]	Prob > F
Foreign Material (%)	5.2	2.7	<0.0001
Loose Shelled Kernels (%)	6.7	4.9	0.0302
Moisture Content (%)	6.4	6.7	0.0013
Total Sound Mature Kernels (%)	73.8	75.4	0.0057
Hulls (%)	21.9	20.9	0.0053
Load-out Rate (MT/hr)	186.7	60.8	<0.0001
Load-out Time (min/truck[b])	7.7	21.6	<0.0001
Trucks per 8-h day	70.9	23.1	<0.0001

[a]Abbreviation: vacuum, vac
[b]Average net peanut weight per truck = 21 MT

warehouse. Upon arrival at the warehouse, an electrician may be required to wire the conveyor's electric motor to a service disconnect.

Depending on how many warehouses are simultaneously used to feed a peanut shelling plant, the loading capacity of the peanut vac may be adequate to fulfil the need. Many times, a shelling plant will draw from multiple warehouses to mitigate the impact of a mechanical failure at any one warehouse on their ability to continuously shell peanuts. In this case, warehouses may only load out 8 to 10 trucks per day. Having the capacity of the articulated front-end loader in this case would likely result in considerable amounts of equipment idle time. The peanut vac may improve clean out when the warehouse is nearly empty and may reduce the risk of an operator puncturing the sheet metal wall or damage to the entrance doors or bulkheads.

Each warehouse operator will have to evaluate the circumstances under which they operate and unload their warehouses. Conventional front-end loaders and conveyor belts, the potato handling equipment, and the peanut vac may all have their niche applications. This research provides data upon which to base their decisions.

Summary and Conclusions

A PTO-powered pneumatic conveyor was used to transfer farmers' stock peanuts from a warehouse into trailers for transport to the shelling plant. Loading capacity and mechanical damage was compared with that of peanuts loaded into trucks using conventional bucket loaders and a conveyor belt. The average time required to load 21 MT of farmers' stock peanuts into a truck was approximately 8 min using conventional equipment compared to approximately 21 min using the pneumatic conveyor. Using the peanut vac to load trucks reduced foreign material and loose shelled kernels compared to conventional loading equipment. This study provided data regarding capacity and mechanical damage caused during warehouse unloading that managers may use in their decisions regarding the purchase of equipment to unload farmers' stock warehouses.

Acknowledgments

The authors gratefully acknowledge Ken and Duane Suaving of Walinga, and Chuck Brothers of Brothers Family Farms LLC, for providing the peanut vac for testing. We also thank Birdsong Peanuts in Colquitt, GA and Golden Peanuts and Tree Nuts located in Ashburn, GA for allowing us to test the equipment while unloading their warehouses and providing the personnel for grading the samples. Finally, we thank the technical support staff at the National Peanut Research Laboratory for their dedicated work and service in completing this research, specifically Mr. John Gardner, Terence Moon, and Dan Todd.

Literature Cited

Blankenship, P. D., and M. C. Lamb, 1996. Handling Farmer Stock Peanuts at Warehouses with Potato Equipment. *Peanut Science* 23:19–23. doi:10.3146/i0095-3679-23-1-4

Butts, C. L., and J.S. Smith. 1995. Shrinkage of Farmers Stock Peanuts During Storage. *Peanut Science* 22:33–41.

Davidson, J. I. Jr., T.B. Whitaker, and J. W. Dickens, 1982. Grading, Cleaning, Storage, Shelling, and Marketing of Peanuts in the United States. In H. E. Pattee, & C. T. Young (Eds.), *Peanut Science and Technology* (pp. 571–623). Yoakum, TX, USA: American Peanut Research and Education Society, Inc. Retrieved from https://apresinc.com/publications/peanut-science-and-technology/

Loewer, O. J., T.C. Bridges, R.A. Bucklin. 1994. On-Farm Materials Handling. In O. J. Loewer, T. C. Bridges, & R. A. Bucklin, *On-*

Farm Drying and Storage Systems (pp. 227-303). St Joseph, MI, USA: American Society of Agricultural Engineers.

Srivastava, A. K., C.E. Goering, R.P. Rohrbach, D.R. Buckmaster. 2006. Conveying of Agricultural Materials. In *Engineering Principles of Agricultural Machines* (2nd ed., pp. 491-524). St. Joseph, MI, United States of America: American Society of Agricultural and Biological Engineers.

United States Department of Agriculture (USDA). 2017. *Farmers Stock Peanuts: Inspection Instructions*. Washington: Specialty Crops Program, USDA, Agricultural Marketing Service.