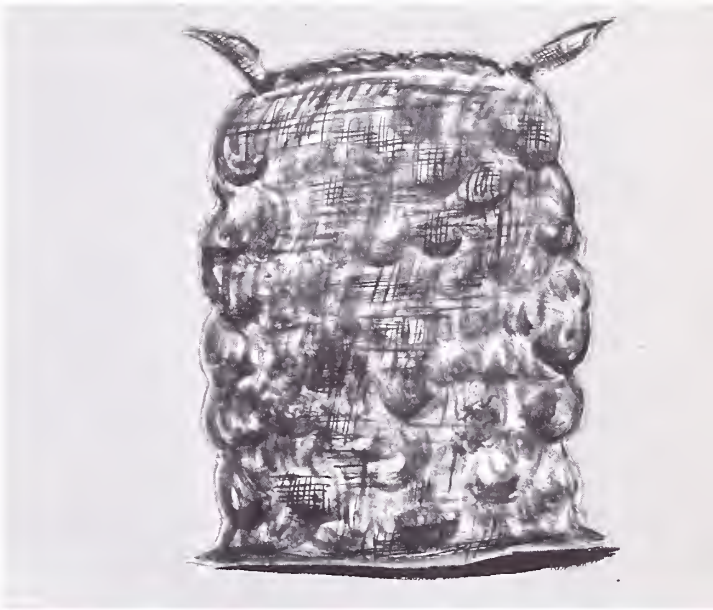
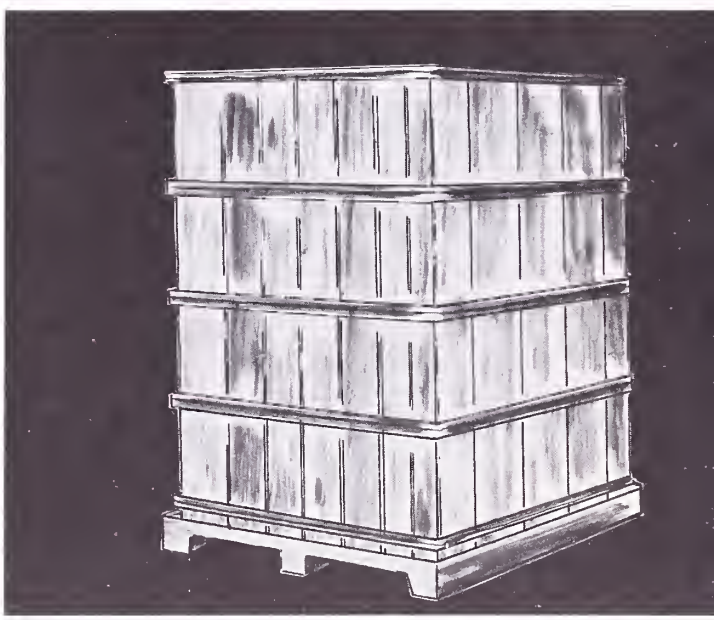
HANDLING AND SHIPPING POTATOES TO PROCESSING PLANTS IN PALLET BOXES AND BURLAP BAGS





Transportation and Facilities
Research Division and
Market Quality Research Division
Agricultural Marketing Service
U. S. Department of Agriculture

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PREFACE

The study on which this report is based is part of a research project covering the development of more efficient work methods, equipment, and facilities for off-farm handling, sorting, cleaning, grading, sizing, and packing fall crop potatoes to reduce costs in the marketing of farm products.

The authors wish to express their appreciation to the Norton Potato Company, East Grand Forks, Minn.; Guy's Nut and Potato Chip Company, Kansas City, Mo.; and the L. A. Phillips Trucking Company, Kansas City, Mo., for making their facilities available and for their cooperation in this study.

The authors wish to acknowledge Alfred D. Edgar, agricultural engineer, Transportation and Facilities Research Division, for his assistance in supplying construction costs for buildings.

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HANDLING AND SHIPPING POTATOES TO PROCESSING PLANTS IN PALLET BOXES AND BURLAP BAGS

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SUMMARY

With more and more potatoes being processed into chips, flakes, granules, and other products it has become increasingly important to develop better methods for moving potatoes from the storage and packinghouses in the producing areas to the processing plants.

This study evaluates handling and shipping potatoes from the packer to the processor by means of bags and pallet boxes and compares the costs of the complete cycle--packer through processor--for labor, equipment, materials, space, injury, transportation between plants, and truck tie-up time. The analysis covers packing, placing 50 percent of potatoes in temporary storage and loading out 50 percent from temporary storage and 50 percent directly from the packing line, placing 100 percent into temporary storage and loading out entirely from temporary storage, and handling by the processor. The costs are based on packing rates of 120 hundredweight (cwt.) and 240 cwt. per hour and annual volumes for these rates of 96,000 cwt. and 192,000 cwt., respectively, for the packer. It was assumed that the processor would use the potatoes at a rate of 60 cwt. per hour and 249,600 cwt. annually. The distance between packer and processor was approximately 700 miles.

The bag method was cheaper than the pallet box method, when considering the above factors only. However, there are increased overhead costs for the indirect loading of bags, losses in transit due to adverse temperatures, and losses of quality from storage. These additional costs may make the pallet box method more economical.

If new bags are used for only one trip instead of three and the bags have a salvage of 5 cents each, the pallet box method costs less than the bag method.

INTRODUCTION

Increased use of potatoes for processing into chips, flakes, granules, and other products has created a greater interest in bulk shipping of potatoes in pallet boxes rather than in 100-pound burlap bags from the grower's storage and packinghouse to the processing plant. One of the methods under development for several years and used today on a limited scale is shipping in 1-ton collapsible wooden pallet boxes.

A study was undertaken to compare costs of handling in pallet boxes and 100-pound bags, from packing and handling by the grower through receiving and handling by the processor, with the objective of developing better handling methods and reducing costs.

This study considers the costs of labor, equipment, materials, shipping full containers to the processor, returning empty containers to the grower, space, injury of the potatoes, and truck tie-up time.

METHODS

100-Pound Burlap Bags

Bags are filled, weighed, handstitched, and placed four high on handtrucks. The bags are then handtrucked and placed into temporary storage until a truck arrives, or are handtrucked and loaded directly into the truck. After a truck arrives and there are potatoes in temporary storage, the packing line is stopped and the entire crew loads the truck. Figures 1 and 2 illustrate filling, handtrucking, and loading the bags directly into the truck.

Ater the truck is loaded, it is driven to the processing plant. Figure 3 shows a truckload of bagged potatoes at the processing plant. This load traveled approximately 700 miles.

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Figure 1.--Bag being filled with 100 pounds of potatoes.

BN-11941

Figure 2.--Handtrucking and stowing bags in the truck.

BN-11942

Figure 3.--Truckload of bagged potatoes at the processing plant.

The bags are then unloaded and placed on 40- x 48-inch pallets, 15 bags per pallet. Portable posts and horizontal rods are placed in every other pallet to permit tiering them two high in storage (figs. 4 and 5).

Potatoes are usually removed from storage one row at a time on a first in, first out basis. A pallet load is removed from storage and placed on a stand by the hopper which feeds the processing line. A worker opens one bag at a time and dumps each bag of potatoes into the hopper (fig. 6).

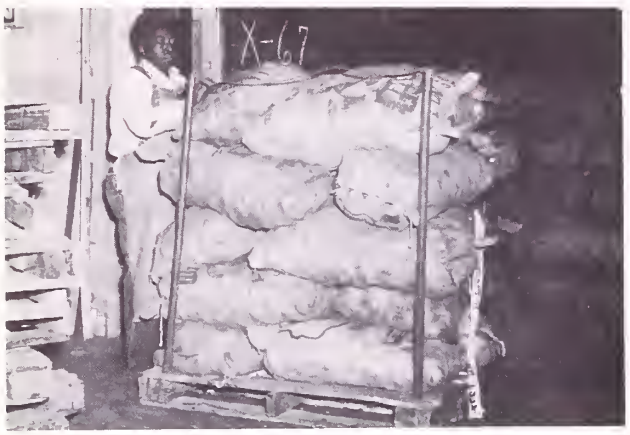

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Figure 4.--Pallet load of bagged potatoes with the pipe or rods installed in the corners.

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Figure 5.--Placing pallet load of bagged potatoes into storage.

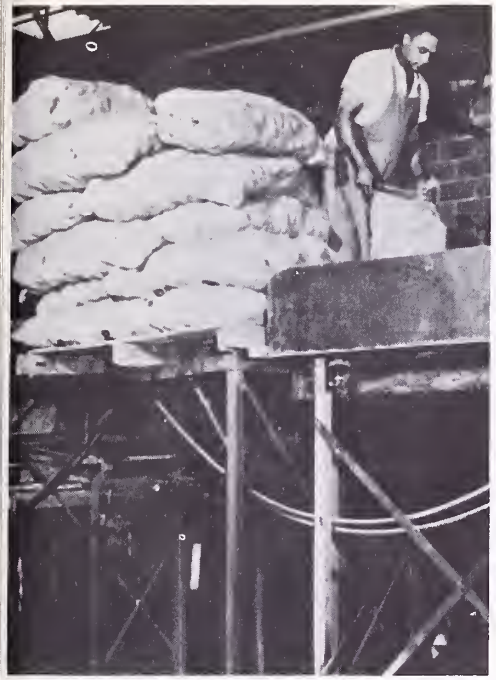

Figure 6.--Emptying bags into the hopper.

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One-Ton Pallet Boxes

Pallet boxes 40 inches wide, 43 inches long, and 60 inches high are filled by placing the box on the box tipper and tilting the box to minimize the drop of the potatoes (figs. 7, 8, and 9). Cleated belt conveyors carry the potatoes from the feed conveyor into the pallet boxes.

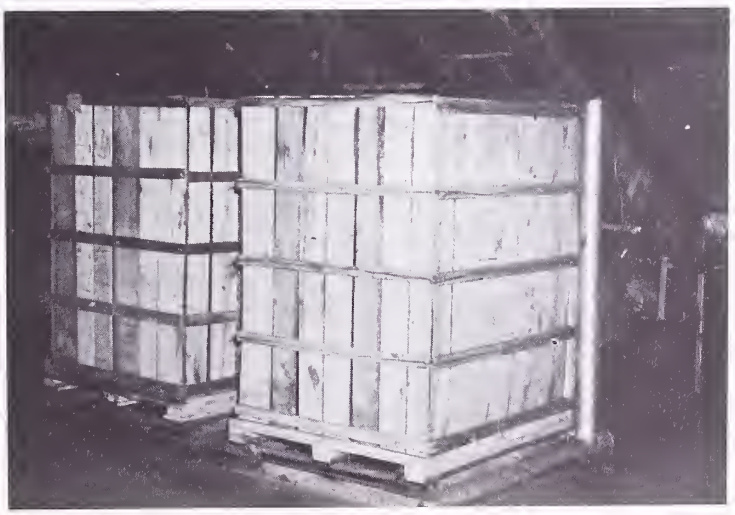

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Figure 7.--Pallet boxes on tipper preparatory to filling.

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Figure 8.--Pallet box on tipper in position to start filling. Forklift truck is picking up full pallet box.

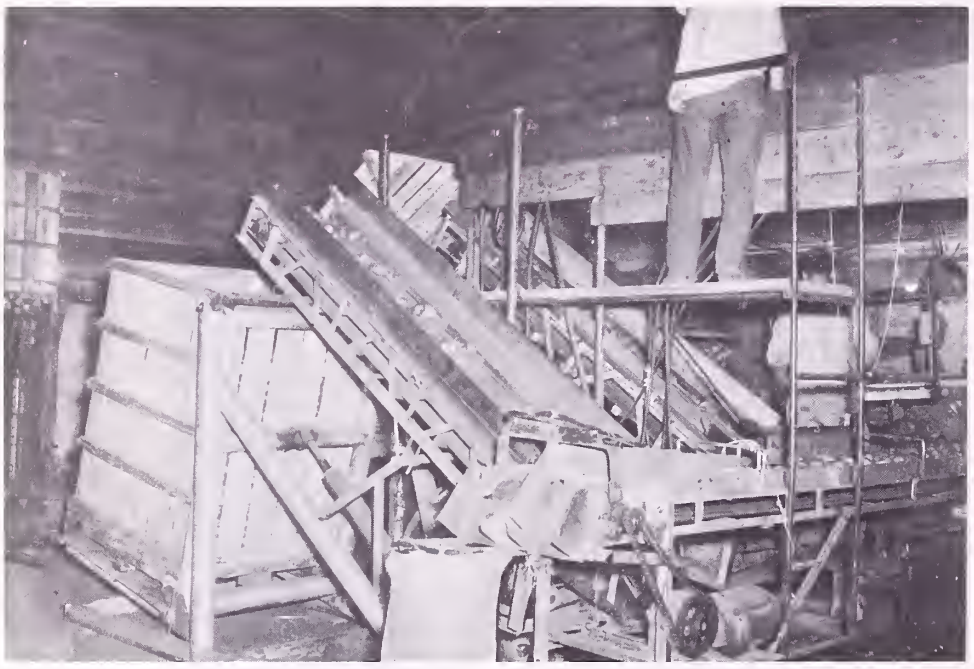

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Figure 9.--Pallet box being filled. Cleated belt conveyor feeds potatoes into pallet box.

After the box is filled it is picked up by a forklift truck and moved into temporary storage, where it is held until a truck arrives, or it is loaded directly into the truck. After a truck arrives, and there are filled pallet boxes of potatoes in temporary storage, the forklift operator loads the truck with pallet boxes from temporary storage. The same forklift truck operator also supplies the packing line with empty boxes, removes the full boxes from the tipper and places them in temporary storage, and supplies the pallet box assemblers with pallets and sides. Figure 10 shows a pallet box being positioned in temporary storage. Figure 11 illustrates a filled pallet box being loaded into the truck. A semitrailer truck having an inside length of 30 feet will hold 16 one-ton pallet boxes.

Pallet boxes are assembled and held together by four wire ties at each of the four corners, and the four sides are fastened to the pallet by a wire tie on each side (figs. 12 and 13).

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Figure 10.--Pallet box of potatoes being placed in temporary storage.

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Figure 11.--A semitrailer truck being loaded with pallet boxes of potatoes.

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Figure 12.--Three sides and the pallet set together. Workers are tying wire at the corners.

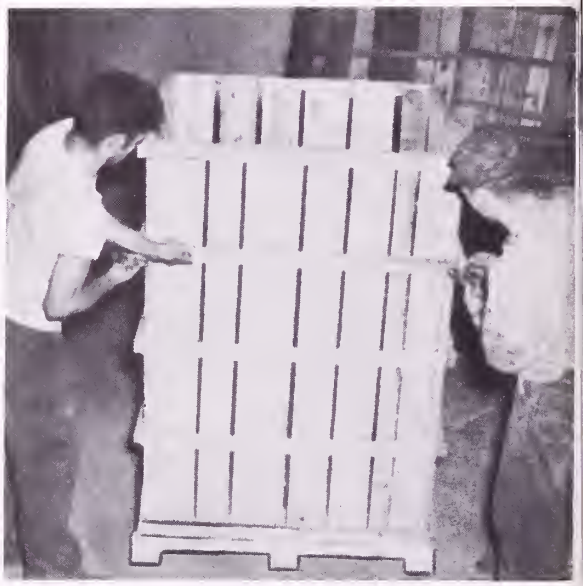

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Figure 13.--Fourth side of pallet box in position. Workers are tying wire at the corners.

After the truck is loaded, it is driven to the processing plant. Figure 14 shows a truckload of potatoes in pallet boxes upon arrival at the processing plant. Travel distance was approximately 700 miles.

The boxes are unloaded, moved to, and placed into temporary storage by use of a forklift truck (figs. 10 and 15).

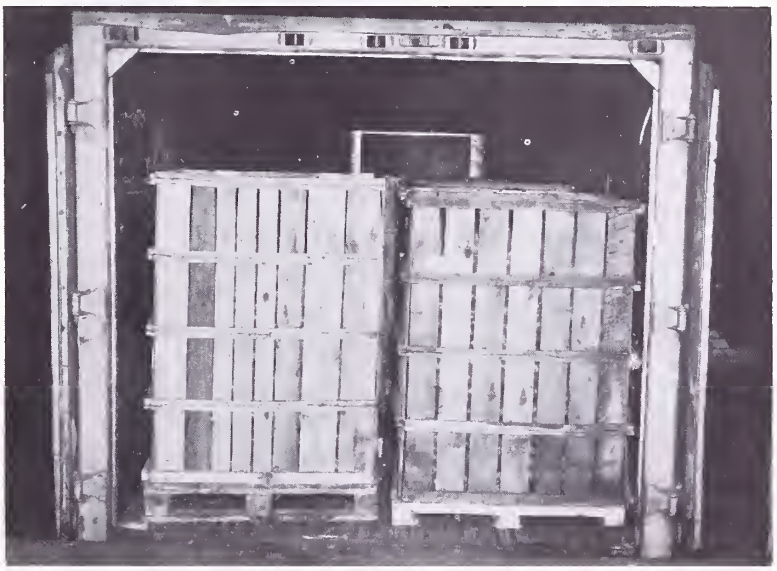

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Figure 14.--Truckload of potatoes in pallet boxes awaiting unloading at the processing plant.

Figure 15.--Pallet boxes of potatoes being unloaded by fork-lift truck.

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Potatoes are usually removed from storage one row of boxes at a time on a first in, first out basis. By means of a forklift truck each pallet box is removed from storage, transported to and placed on the box tipper at the hopper, which feeds potatoes to the processing line (fig. 16). The box is tipped and the potatoes emptied into the hopper (fig. 17).

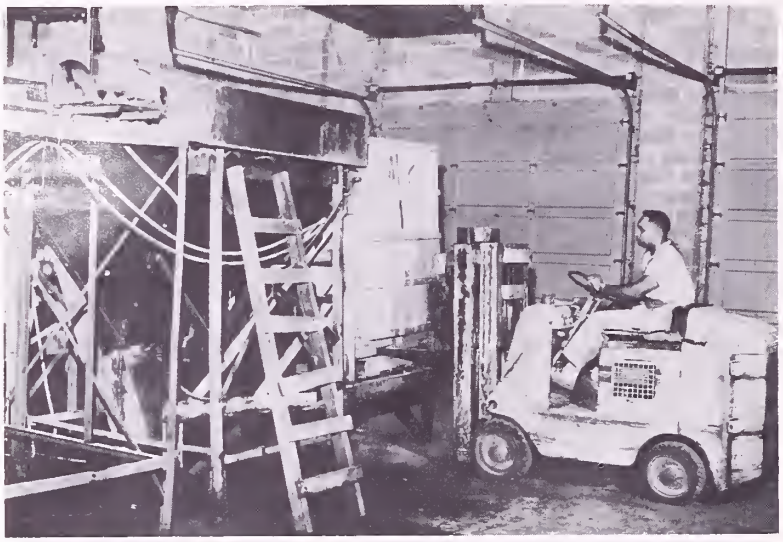

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Figure 16.--Pallet box of potatoes being placed on the box tipper at the hopper, which feeds the processing line.

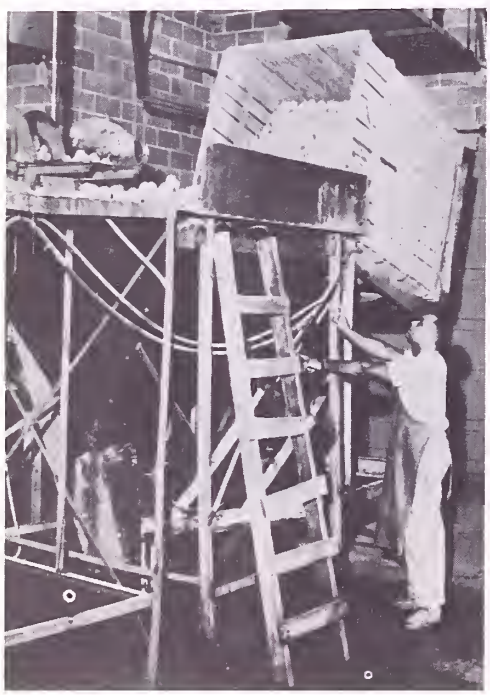

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Figure 17.--Emptying a pallet box of potatoes into the hopper.

After the box has been emptied and lowered, it is removed from the tipper, moved to the disassembly areas, and disassembled (fig. 18). When a truckload of "knocked-down" or disassembled boxes is accumulated, the boxes are loaded into a truck and transported back to the packer. At the storage and packing plant the truckload of knocked-down boxes (fig. 19) is unloaded and the sides and pallets are stacked near the box assembly area.

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Figure 18.--Disassembling a pallet box at the processing plant.

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Figure 19.--Unloading disassembled pallet boxes at the storage.

MECHANICAL INJURY

The extent of mechanical injury to potatoes handled by the two different methods was estimated by inspecting 20 random samples of 25 pounds each for each method. The samples were obtained from the feed hopper of the chip line. To make the sample more nearly representative of the lot, samples were obtained from the top, middle, and bottom of several 1-ton pallet boxes and from the top, middle, and bottom bags of several pallet loads of 100-pound bags. The injuries were classified as slight, moderate, or severe. Potatoes were considered slightly bruised if the injured portion could be removed with a loss of less than 5 percent in original weight (within the tolerance of U. S. No. 1 grade), moderately bruised if the injured portion could be removed with a loss of 5 to 10 percent (within the tolerance for U. S. No. 2 grade but not for U. S. No. 1), and severely bruised if the injured portion could not be removed without loss of more than 10 percent of the potato (not within the tolerance of U. S. No. 2 grade).

These injury studies were conducted with a single lot of Kennebec potatoes which had been stored about a month at moderate temperatures prior to grading. The potatoes were graded on October 28, 1959, at East Grand Forks, Minn., placed in temporary storage, and then shipped by truck trailer to Kansas City, Mo., October 30. The loads arrived at the processing plant November 2. Samples were obtained and inspected on November 3, 4, and 5.

The injury recorded includes that which took place in harvesting, storing, grading, transporting, warehouse handling, and dumping into the hopper feeding the processing line, since new bruises could not be distinguished from old bruises at the time of examination. Since the potatoes in both methods of handling were from the same lot and were handled identically until they were placed in the shipping containers, any differences in injuries could be attributed to subsequent handling and to shipping containers.

The data obtained were converted into nongrade defects (within the tolerance of U. S. No. 1 grade), grade defects (outside the tolerance of U. S. No. 1 grade), total defects, and a bruising index. The bruising index was obtained by multiplying the percentage of potatoes with slight bruises by 0.1, that of moderate bruises by 0.5, and that of severe bruises by 1.0. These values were then totaled to give the index. The larger the index the greater the amount and severity of bruising.

Statistical significance of the results was determined by a method given by Snedecor for unpaired data. 1/

As shown in table 1, potatoes handled in 100-pound bags had significantly more nongrade defects, grade defects, total defects, and a higher bruising index than those handled in the 1-ton pallet boxes. 2/

1/ Snedecor, G. W. Statistical Methods. Ed. 4. Iowa State College Press, Ames, pp. 76-78, 1948.

2/ The odds that the differences in injury between the two methods of handling were not due to chance were greater than 99 to 1 for the nongrade defects, total defects, and bruising index; and greater than 19 to 1 for the grade defects.

Table 1.--Injury in Kennebec potatoes handled in 100-lb. bags and in 1-ton pallet boxes, November 1959

Treatment	Nongrade defects	Grade defects	Total defects	Bruising index
	Percent	Percent	Percent	
100-lb. bags	76.2	9.8	86.0	13.21
1-ton boxes	68.4	6.6	75.0	10.43
Difference	1/ 7.8	2/3.2	1/11.0	1/ 2.78

1/ Difference significant at 0.01 level.
2/ Difference significant at 0.05 level.

In any evaluation of the losses incurred from mechanical injuries, consideration must be given to the nongrade defects, for although the losses due to the removal of the defects may be minor, mechanical injuries of any kind pave the way for the entrance of various decay-producing organisms which may cause further losses.

The potatoes used in this study had been held at moderate temperatures from harvest until marketed. It was apparent at the time of examination that they had lost considerable weight and were not as turgid as freshly harvested potatoes or those held at cooler temperatures, and, therefore, were not so susceptible to bruising. Had the potatoes been more susceptible to bruising even greater differences between the two methods may have resulted.

COMPARATIVE COSTS

In the study of costs of these two methods, it is considered that the cycle begins with filling the bags and pallet boxes at the packing plant. All operations preceding this, such as sorting on the sorting table and supplying the packing line with potatoes, are considered to be the same for both methods and are not included. All operations from filling through the complete cycle and back to filling are included. The study at the processing plant is limited to all operations up to and including supplying the processing line with potatoes. All operations following this are considered the same for both methods.

Costs are based on packing and handling rates at the packing plant of 120 and 240 hundredweight (cwt.) per hour, 960 and 1,920 cwt. per day for 100 days, and an annual volume of 96,000 and 192,000 cwt. Handling to and supplying the processing lines is considered at 60 cwt. per hour, 960 cwt. per day for 260 days, and an annual volume of 249,600 cwt.

Figure 20 shows a layout used for the bag operation at the packing plant with temporary storage for 2,320 cwt., or 2.42 days' supply of packing at 120 cwt. per hour or 1.21 days at 240 cwt. per hour.

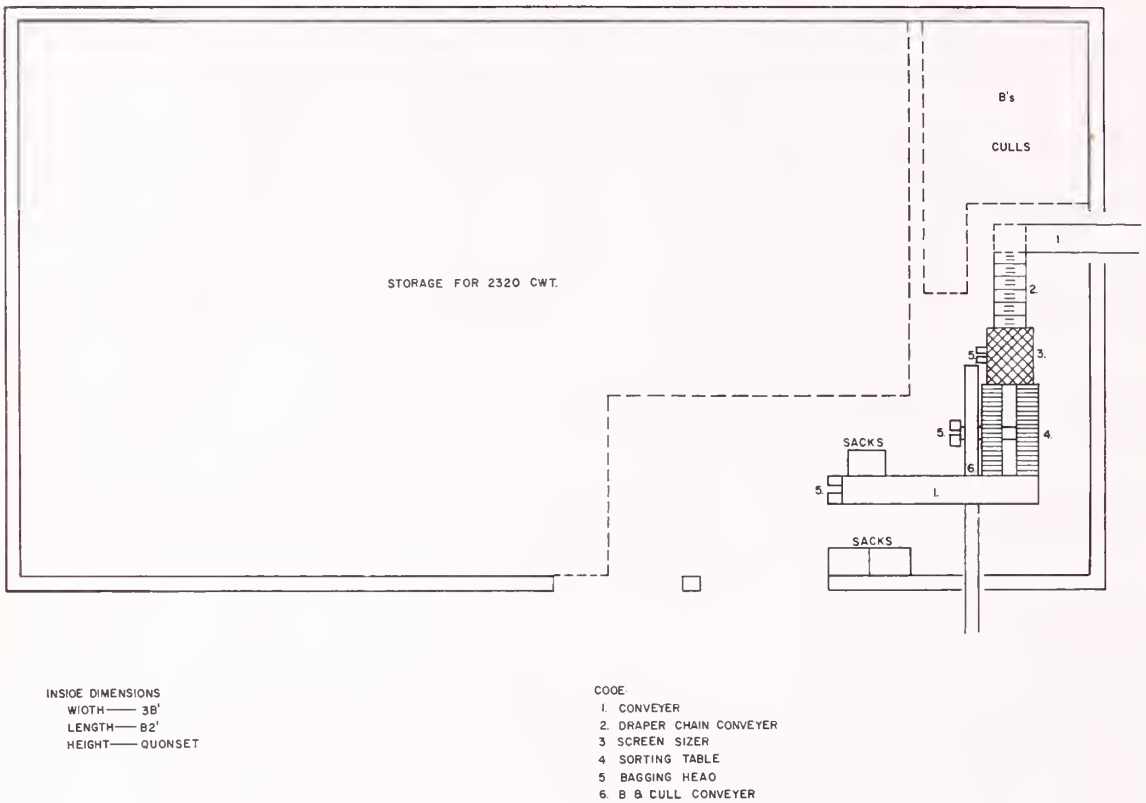

Figure 20.--Layout for the bag operation at the packing plant.

Figure 21 shows a layout used for the bag operation at the processing plant with temporary storage for 6,390 cwt. or 6.66 days' supply at a usage rate of 60 cwt. per hour or 960 cwt. per day.

Figure 22 shows a layout used for the pallet box operation at the packing plant with temporary storage for 2,320 cwt. or 2.42 days' supply of packing at 120 cwt. per hour or 1.21 days' supply at 240 cwt. per hour.

Figure 23 gives a layout used for the pallet box operation at the processor with temporary storage for 6,420 cwt. or 6.69 days' supply at a usage rate of 60 cwt. per hour or 960 cwt. per day.

Although it was intended for the comparative study to allow for approximately 1 to 1¼ days' storage for each packing rate, the same layout was used for both packing rates of 120 and 240 cwt. per hour, due to the low cost of the additional space and allowing for future increase in production.

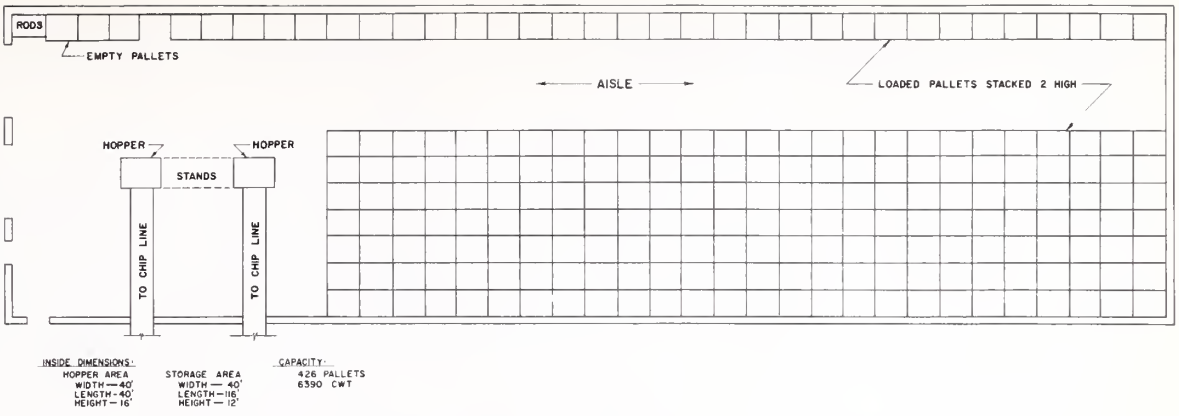

Figure 21.--Layout for the bag operation at the processing plant.

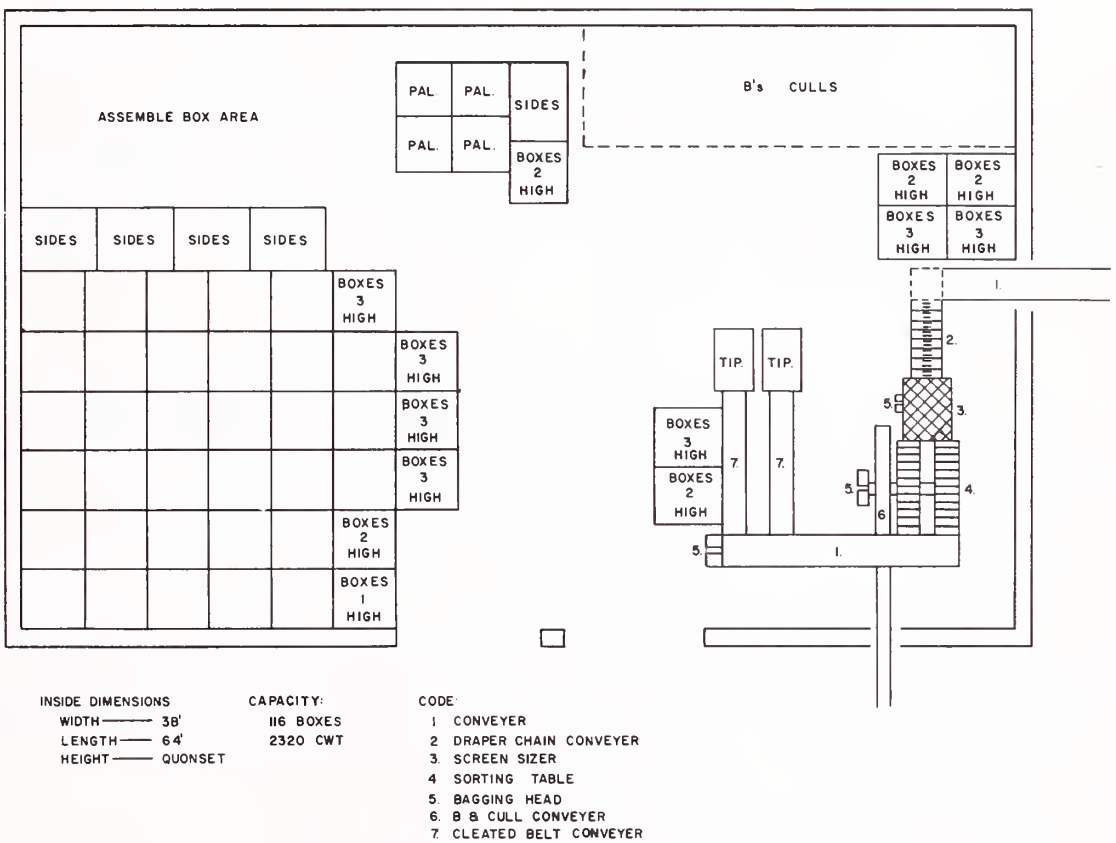

Figure 22.--Layout for the pallet box operation at the packing plant.

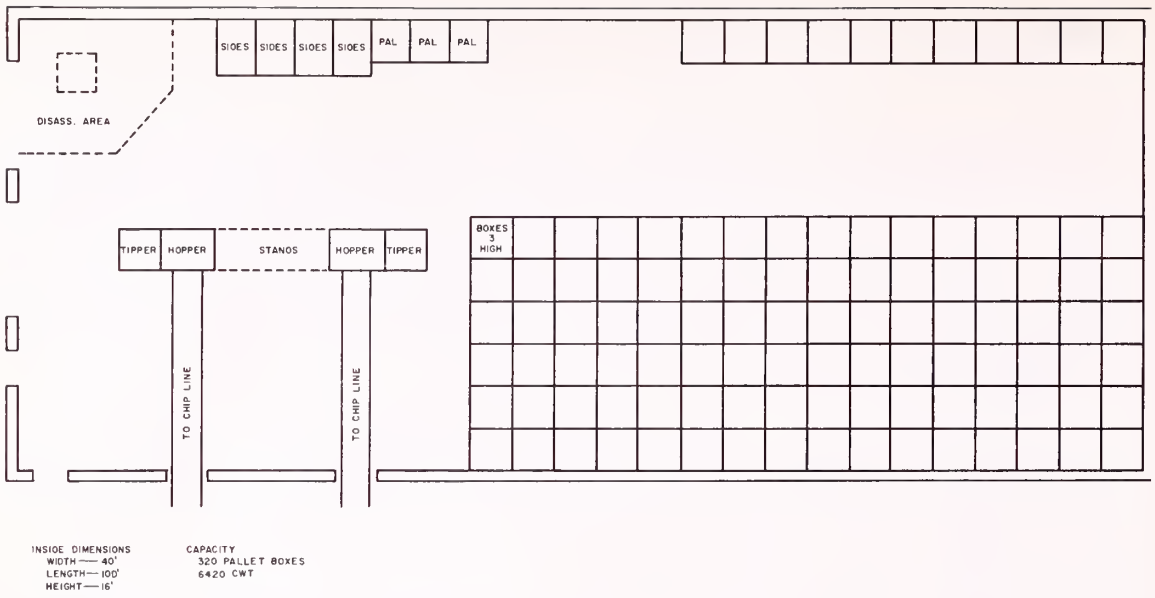

Figure 23.--Layout for the pallet box operation at the processing plant.

A truckload is considered to hold 330 cwt. of bagged potatoes and 320 cwt. in pallet boxes (16 pallet boxes per truckload). This could vary depending on the size of the truck and the legal length and load limits of the State or States in which the truck operates.

Labor

Time studies of these operations were made in accordance with approved techniques by the use of a stopwatch. The actual times observed on elements of work were leveled by a performance rating to represent an average qualified worker working at a normal rate. To these times, additional times were added for fatigue and personal requirements.

From these time study data, labor costs for the specified methods and types of equipment have been computed. Labor costs shown are based on the productive labor required plus the amount of idle time inherent in the method.

An assumed wage rate of $1 per hour is used for all operations at the packinghouse and $1.45 per hour at the processing plant.

At the Packing Plant

Bag Method

Packing 120 cwt. per hour.--Bags are filled, weighed, handstitched, handtrucked into temporary storage, handtrucked and loaded out from temporary storage, and handtrucked and loaded directly from the packing line. When loading out direct, the handtrucker handtrucks and loads out during the packing

operation. When bags are loaded out from temporary storage, the packing line is stopped and five men of the crew handtruck and load out the bags.

At this packing rate a 3-man crew is required: One sack filler, one weigher-stitcher, and one handtrucker, who also sacks the B-size potatoes. Usually there are two sorters on the sorting table (depending on the quality of potatoes being sorted). When handtrucking and loading out from temporary storage at these distances, a 5-man crew is most efficient. Labor cost of the sorters is included only while they assist in loading out from temporary storage. While the line is stopped, workers who supplied the packing line from storage perform other tasks such as cleaning up dirt.

Labor cost for packing and placing 50 percent into temporary storage, then loading out from temporary storage; and loading 50 percent directly into the truck.....$0.0293 per cwt.

Labor cost for packing and placing 100 percent into temporary storage, then loading out from temporary storage.....$0.0336 per cwt.

Packing 240 cwt. per hour.--At a packing rate of 240 cwt. per hour, a 7-man crew is required when placing 50 percent into temporary storage, then loading out from temporary storage, and loading 50 percent directly into the truck: One sack filler, one weigher, two stitchers, two handtruckers, and one B-sacker. When placing 100 percent into temporary storage, then loading out one less handtrucker is required, making a 6-man crew. Usually there are four sorters on the sorting table (depending on the quality). When loading out from temporary storage, five men load and five men operate the line at half capacity.

Labor cost for packing and placing 50 percent into temporary storage, then loading out from temporary storage; and loading 50 percent directly into the truck.....$0.0339 per cwt.

Labor cost for packing and placing 100 percent into temporary storage, then loading out from temporary storage.....$0.0336 per cwt.

Pallet Box Method

Packing 120 and 240 cwt. per hour.--Boxes are assembled, filled, placed into temporary storage, and loaded out from temporary storage or directly from the packing line. Disassembled boxes are unloaded from the truck when a truck-load arrives.

To pack 120 cwt. per hour, a 3-man crew is required: One man operates the box tippers and handles the B-size potatoes, one man assembles boxes, and one man operates the forklift truck and assists in assembling boxes.

To pack 240 cwt. per hour, a 6-man crew is required: One man operates the box tippers and handles B-size potatoes, four men assemble boxes, and one man operates the forklift truck.

Labor cost for packing at a rate of 120 or 240 cwt. per hour and placing 50 percent into temporary storage, then loading out from temporary storage, and loading 50 percent directly into the truck; or placing 100 percent into temporary storage, then loading out.....$0.0250 per cwt.

At the Processing Plant

Bag Method

Processing 60 cwt. per hour.--Sacks are unloaded from the truck and placed on pallets. The pallets are transported and placed in storage, removed from storage and taken to the processing line, where the sacks are opened and emptied into the hopper of the line.

This requires a 3-man crew. Two men unload and place sacks on pallets and empty bags into the hopper of the processing line only while the truck is being unloaded. One forklift operator handles potatoes into and out of storage and empties bags into the hopper of the line while the truck is not there. Consequently, the two bag handlers work on this operation 1.54 hours per truckload of 330 cwt. processed in 5.50 hours. Labor costs for these two men are based on 1.54 hours out of every 5.50 hours. It is considered that other work in the plant is available for these two men. The labor cost for three men is $0.0377 per cwt.

Pallet-Box Method

Processing 60 cwt. per hour.--This operation consists of unloading 16 pallet boxes from the truck, transporting and placing them into storage, removing them from storage and supplying the line with potatoes, operating the box tipper and dumping the potatoes into the hopper of the processing line, disassembling and storing empty boxes, and loading disassembled boxes into a truck when a truckload has been accumulated.

This requires one man and a forklift truck. The labor cost is $0.0242 per cwt.

Equipment

Purchase prices of handling equipment are f.o.b. Grand Forks, N. Dak. The same prices were used for the packer and processor. Equipment costs were developed into two major categories: Ownership and operational.

Ownership costs include depreciation, taxes, interest, and insurance, all considered to be fixed. They are computed on an annual basis. Interest on the average investment is fixed at 5 percent and 4 percent is allowed for insurance and taxes.

Operational costs include maintenance, repairs, inspection and servicing, fuel, oil, and electricity. The costs for maintenance, repair, inspection, and

servicing for all units was fixed at 1½ percent of the replacement cost per 100 hours of use, except for the following: (a) 2,000-pound-capacity forklift truck at $0.174 per hour of use; (b) 3,000-pound-capacity forklift truck at $0.184 per hour of use; (c) pallets for bags at $0.0075, vertical posts for pallets at $0.0002, horizontal rods for pallets at $0.0006 each time of use, and (d) stand at $2.50 per year. Gasoline cost was considered at $0.23 per gal. and oil at $0.40 per qt. Electricity cost was considered at $0.02 per kw.-hr.

Although a gasoline-powered forklift truck was used in this comparison it is not recommended in closed atmospheres. A gasoline truck with bottled-gas (LP) unit is much safer. An electric forklift truck would eliminate all possibilities of carbon monoxide.

Costs of owning and operating equipment for both methods and for various volumes are presented in tables 2 through 7.

Materials

Pallet Box Method

The collapsible pallet box used in this method is a wirebound type made of poplar wood with 3/8-inch-thick sides. The cleats are 1-1/8 inches wide and 1-5/8 inches high. The pallet is made of nominal 1-inch boards on 2 by 4's lying flat. The 2 by 4's are faced with a 1-inch board to allow entry room for the forks of the forklift truck. The outside dimensions are 40 inches wide by 43 inches long by 60 inches high including the pallet. The empty pallet box weighs approximately 140 pounds. It is assembled and held together by four wire ties at each of the four corners and the four sides are fastened to the pallet by a wire tie for each side.

The elapsed time required to assemble the box (including 0.50 minute for repair per trip) for one man is 0.2792 hour; for two men 0.1444 hour.

The elapsed time required for one man to disassemble the box is 0.10 hour.

The box is considered to have an expected life of 60 round trips. Cost of the box on a cwt. basis depends on the number of trips a box makes during the year. The number of boxes required to complete the cycle of operations depends on the following: (1) The number of boxes required for temporary storage of the potatoes by the packer and processor; (2) supply of empty boxes accumulated by both the processor and the packer until a truckload is available; and (3) number of full and empty boxes in transit between the packer and the processor.

At a packing rate of 120 cwt. per hour and approximately 1.25 days' supply for temporary storage, and at a processing rate of 60 cwt. per hour and approximately 6.66 days' supply for temporary storage, 726 boxes are required to fill the cycle. Packing 240 cwt. per hour, and supplying two plants which process 60 cwt. per hour each, requires 1,452 boxes. At packing rates of 96,000 cwt. and 192,000 cwt. per year, when the packer owns the boxes, each box would make 6.61 trips per year. The expected life of the box would be 9.07 years.

Table 2.--Ownership and operation costs for equipment used at a packing plant when using the burlap bag method and packing 120 cwt. of potatoes per hour, 960 cwt. per day, 96,000 cwt. per year, for 100 days of operation

Equipment and quantity	Initial cost	Expected life	Ownership cost				Operating cost (maintenance)	Total annual cost	Cost per cwt.
			Depreciation	Interest at 5%	Insurance and taxes at 4%	Total			
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Bagging heads (2)	25.00	20	1.25	0.63	1.00	2.88	0.30	3.18	--
Scales (1)	102.00	20	5.10	2.55	4.08	11.73	2.94	14.67	--
Handtrucks (5)	200.00	20	10.00	5.00	8.00	23.00	10.78	33.78	--
Total	327.00	--	16.35	8.18	13.08	37.61	14.02	51.63	0.0005

Table 3.--Ownership and operation costs for equipment used at a packing plant when using the burlap bag method and packing 240 cwt. of potatoes per hour, 1,920 cwt. per day, 192,000 cwt. per year, for 100 days of operation

Equipment and quantity	Initial cost	Expected life	Ownership cost				Operating cost (maintenance)	Total annual cost	Cost per cwt.
			Depreciation	Interest at 5%	Insurance and taxes at 4%	Total			
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Bagging heads (2)	25.00	15	1.67	0.63	1.00	3.30	0.60	3.90	--
Scales (1)	102.00	15	6.80	2.55	4.08	13.43	5.88	19.31	--
Handtrucks (7)	280.00	15	18.67	5.00	8.00	31.67	21.56	53.23	--
Total	407.00	--	27.14	8.18	13.08	48.40	28.04	76.44	0.0004

Table 4.--Ownership and operation costs for equipment used at a processing plant when using the burlap bag method and processing 60 cwt. of potatoes per hour, 960 cwt. per day, 249,600 cwt. per year, for 260 days of operation

Equipment and quantity	Initial cost	Expected life	Ownership cost				Operating cost			Total annual cost	Cost per cwt.
			Depreciation	Interest at 5%	Insurance and taxes at 4%	Total	Power	Maintenance	Total		
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Forklift truck, 2,000-lb. capacity (1)	3,885.00	5	777.00	97.13	155.40	1,029.53	333.93	282.05	615.98	1,645.51	0.0066
Pallets (426 at $4.00 each)	1,704.00	10	170.00	42.60	68.16	280.76	--	124.60	124.60	405.36	.0016
Posts (852) for pallets	1,533.60	20	76.68	38.34	61.34	176.36	--	5.15	5.15	181.51	.0007
Horizontal rods (852) for pallets	426.00	10	42.60	10.65	17.04	70.29	--	20.59	20.59	90.88	.0004
Stands (2)	310.00	20	15.50	7.75	12.40	35.65	--	5.00	5.00	40.65	.0002
Total	7,858.60	--	1,081.78	196.47	314.34	1,592.59	333.93	437.39	771.32	2,363.91	.0095

Table 5.--Ownership and operation costs for equipment used at a packing plant when using the pallet box method and packing 120 cwt. of potatoes per hour, 960 cwt. per day, 96,000 cwt. per year, for 100 days of operation

Equipment and quantity	Initial cost	Expected life	Ownership cost				Operating cost			Total annual cost	Cost per cwt.
			Depreciation	Interest at 5%	Insurance and taxes at 4%	Total	Power	Maintenance	Total		
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Forklift truck, 3,000-lb. capacity (1)	5,355.00	15	357.00	133.88	214.20	705.08	68.62	49.13	117.75	822.83	0.0086
Box tippers (2)	1,187.00	15	79.13	29.68	47.48	156.29	--	71.22	71.22	227.51	.0024
Cleated belt conveyors (2)	880.00	10	88.00	22.00	35.20	145.20	5.97	52.80	58.77	203.97	.0021
Box tipper motor (1)	135.00	15	9.00	3.38	5.40	17.78	35.80	16.20	52.00	69.78	.0007
Total	7,557.00	--	533.13	188.94	302.29	1,024.35	110.39	189.35	299.74	1,324.09	.0138

Table 6.--Ownership and operation costs for equipment used at a packing plant when using the pallet box method and packing 240 cwt. of potatoes per hour, 1,920 cwt. per day, 192,000 cwt. per year, for 100 days of operation

Equipment and quantity	Initial cost	Expected life	Ownership cost				Operating cost			Total annual cost	Cost per cwt.
			Depreciation	Interest at 5%	Insurance and taxes at 4%	Total	Power	Maintenance	Total		
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Forklift truck, 3,000-lb. capacity (1)	5,355.00	10	535.00	133.88	214.20	883.08	137.24	98.25	235.49	1,118.57	0.0058
Box tippers (2)	1,187.00	15	79.13	29.68	47.48	156.29	--	71.22	71.22	227.51	.0012
Cleated belt conveyors (2)	880.00	10	88.00	22.00	35.20	145.20	5.97	52.80	58.77	203.97	.0010
Box tipper motor (1)	135.00	15	9.00	3.38	5.40	17.78	35.80	16.20	52.00	69.78	.0004
Total	7,557.00	--	711.13	188.94	302.28	1,202.35	179.01	238.47	417.48	1,619.83	.0084

Table 7.--Ownership and operation costs for equipment used at a processing plant when using the pallet box method and processing 60 cwt. of potatoes per hour, 960 cwt. per day, 249,600 cwt. per year, for 260 days of operation

Equipment and quantity	Initial cost	Expected life	Ownership cost				Operating cost			Total annual cost	Cost per cwt.
			Depreciation	Interest at 5%	Insurance and taxes at 4%	Total	Power	Maintenance	Total		
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Forklift truck, 3,000-lb. capacity (1)	5,355.00	7	765.00	133.88	214.20	1,113.08	291.70	208.84	500.54	1,613.62	0.0065
Box tippers (2)	1,187.00	15	79.13	29.68	47.48	156.29	--	18.52	18.52	174.81	.0007
Box tipper motor (1)	135.00	15	9.00	3.38	5.40	17.78	9.31	4.21	13.52	31.30	.0001
Total	6,677.00	--	853.13	166.94	267.08	1,287.15	301.01	231.57	532.58	1,819.73	.0073

Purchase cost of the pallet box is considered at $11.55 f.o.b. Grand Forks, N. Dak. With interest at 5 percent on the average investment and allowing 3 percent for insurance and taxes over 9.07 years, the ownership cost per year is $1.913 per pallet box and at 6.61 trips (132.2 cwt.) it is $0.0145 per cwt.

Material for repairing pallet boxes costs $0.04 per box per trip. Labor cost for repairing boxes, $0.0083 per box per trip, was included with assembly costs. At $0.04 per trip and at 6.61 trips per year the cost is $0.2644 per year or $0.0020 per cwt. Wire costs of $0.0274 per box per trip are $0.1810 per year or $0.0014 per cwt. The cost of repairing the box is $0.4454 per year or $0.0034 per cwt. Consequently, the total ownership and operational cost of one box per year is $2.358 or $0.0178 per cwt.

Bag Method

A burlap bag when purchased new is considered as having an expected life of three round trips in this method. The number of bags required in the complete cycle is determined in the same way as for pallet boxes with the exception of accumulating empty bags. This should be based on a smaller shippable unit than a truckload, probably a packing day's supply for one processing plant such as 960 cwt.

At a packing rate of 120 cwt. per hour and approximately 1.25 days' supply in temporary storage and a processing rate of 60 cwt. per hour and 6.66 days' supply in temporary storage, 11,254 bags are required. At 240 cwt. per hour and supplying two plants each processing 60 cwt. per hour 22,508 bags are required. At annual volumes of 96,000 and 192,000 cwt., each bag would make three round trips in 0.35 year.

The cost of a new bag is assumed at $0.15 f.o.b. Grand Forks, N. Dak. Charges of $0.0025 per bag per trip for return, $0.0003 for insurance, and $0.0005 for stitching twine and needles increase the cost per bag to $0.1706. This prorated over three trips equals $0.0568 per cwt.

Space

Space costs for the packinghouse were estimated for a quonset building, which was considered the most economical building for both the bag and pallet-box methods.

Processing plants are usually in cities, towns, and commercial areas where building costs are high. The costs vary according to location. To arrive at a building cost for the processor, the cost of the building was estimated to be double that for the packer. The type of building used in the comparison for processing plants in these areas was a vertical-wall building with a clear span roof.

The same storage space was included in the layout for both packing rates of 120 and 240 cwt. per hour due to the low cost of the additional space and allowing for future increases in production.

Layouts of each method were developed to allow the necessary space to perform the operations most efficiently and included space for temporary storage of 1.25 days at the packinghouse and 6.66 days at the processing plant. The temporary storage for the packer and processor was not intended for conditioning potatoes for processing, although it can be used for conditioning to a limited extent. It is considered that potatoes have been conditioned for processing when packed.

To develop a total annual cost for space, the cost of the building was estimated and depreciated over 25 years; interest of 5 percent of the average investment was added; 3 percent was allowed for taxes and insurance, and 0.5 percent per year of the initial cost was used for maintenance.

The total annual cost was divided by the cubic footage to arrive at a cost per cubic foot of space available. It was also divided by the annual volume to arrive at a cost per cwt.

The packing building illustrated in figure 20 for the bag operation has inside dimensions 38 feet wide and 82 feet long with a total inside volume of 46,500 cubic feet.

For this building the annual cost is $0.0241 per cubic foot. At an annual volume of 96,000 cwt. the building cost is $0.0117 per cwt. and at an annual volume of 192,000 cwt. the cost is $0.0058 per cwt.

Inside dimensions for the packing building (fig. 22) for the pallet box operation are 38 feet wide by 64 feet long and the building has a total inside volume of 36,300 cubic feet. For this building the annual cost per cubic foot is $0.0238 and at an annual volume of 96,000 cwt. amounts to $0.0090 per cwt. and for an annual volume of 192,000 cwt. amounts to $0.0045 per cwt.

The processing building for the bag operation (fig. 21) has inside dimensions in the hopper area 40 feet wide by 40 feet long by 16 feet high and in the storage area 40 feet wide by 116 feet long by 12 feet high. The total inside volume is 81,280 cubic feet. The annual cost of space is $0.0568 per cubic foot. At an annual volume of 249,600 cwt. the cost is $0.0186 per cwt.

The processing building for the pallet box operation (fig. 23) has inside dimensions 40 feet wide by 100 feet long by 16 feet high, and a total inside volume of 64,000 cubic feet. The annual cost for space is $0.0500 per cubic foot, or $0.0128 per cwt. at an annual volume of 249,600 cwt.

Transportation

The cost of transporting a pallet box filled with potatoes and returning the collapsed box to the packer will depend on the arrangement that can be made by the packer and processor with the trucking company.

Transportation cost for the tare weight of the pallet box when filled with potatoes is considered to be the same on a per cwt. basis as the transportation cost of the potatoes. In this study a rate of $0.90 per cwt. was used for

transporting potatoes and boxes approximately 700 miles. Since the tare weight of the pallet box is 140 pounds, the cost of transporting the box only when filled with potatoes from the packer to the processor is $1.26 (1.4 x $0.90) for the box, or an equivalent of $0.0630 per cwt. of potatoes transported in the box.

A cost of $100 per truckload of 126 collapsed pallet boxes is used for return of the boxes to the packer. This is equivalent to $0.0397 ($100/126 x 20) per cwt. of potato capacity. Thus the cost of transporting the container both ways amounts to $0.1027 per cwt. of capacity.

No transportation cost was used for burlap bags when filled with potatoes since trucking companies hauling from this area usually charge only for the weight of the potatoes when shipping in burlap bags.

A cost of $0.0025 per bag per trip for returning bags to the packer was included with the materials cost.

Injury

It was assumed that an additional 3.2 pounds out of every 100 pounds has a trim loss of 10 percent or 0.32 pound per cwt. in the bag method as compared to the pallet box method.

The same loss rate was used when placing 50 or 100 percent into storage before loading out. Decreased handling when loading directly into the truck from the packing line should reduce injury, particularly with the bag method.

In determining monetary losses due to injury, an assumed value of $0.03 per pound was multiplied by 0.32 pound to arrive at a value of $0.0096 per cwt. for the increased loss due to injury by the bag method as compared to the pallet box method.

Truck Tie-Up

A truck standing at a dock either waiting or actually being loaded or unloaded, is a cost to the transportation company. Reducing waiting time and time to load and unload reduces costs for the transportation company. The amount of savings realized depends on the transportation schedule of the company. In this study, cost of the truck and tractor while being loaded or unloaded at the dock was valued at $8 an hour.

Potatoes must sometimes be placed into temporary storage until a truck is available. Consequently, costs of labor, equipment, and space at packing rates of 120 and 240 cwt. per hour were developed for placing 50 percent into temporary storage and then loading out, and loading 50 percent directly from the packing line. Costs were also developed for placing all the potatoes into temporary storage and then loading out from storage, to minimize the truck loading time.

The tie-up times to load and unload trucks are:

Item	Truck tie-up time (hours)
Five men load out truckload of 330 bags from temporary storage	0.569
One man loads truck with 330 bags direct from packing line:	
Packing at a rate of 120 cwt. per hour	2.750
Two men load out truck with 330 bags direct from the packing line:	
Packing at a rate of 240 cwt. per hour	1.375
One man with a forklift truck loads out truck with 16 pallet boxes from temporary storage and removes full boxes from packing line, places in temporary storage, supplies packing line with empty boxes, and supplies assemblers with collapsed boxes during loading out of truck:	
Packing rate of 120 cwt. per hour	0.344
Packing rate of 240 cwt. per hour	0.400
One man with a forklift truck loads truck with 16 boxes direct from packing line, supplies packing line with empty boxes, and supplies box assemblers with collapsed boxes:	
Packing rate of 120 cwt. per hour	2.666
Packing rate of 240 cwt. per hour	1.333
One man with a forklift truck unloads truckload of 126 collapsed pallet boxes, removes full boxes from packing line, loads directly into truck or places into temporary storage, supplies line with empty boxes, and supplies box assemblers with collapsed boxes during unloading of truck:	
Load full boxes into truck or place in storage, packing rate of 120 cwt. per hour	1.027
Load full boxes into truck or place in storage, packing rate of 240 cwt. per hour	1.189
One man with a forklift truck and 2 other men unload 330 bags onto pallets, place into storage, and supply processing line with potatoes at a rate of 60 cwt. per hour:	
Truck time	1.387
3-man crew time	1.540
One man with a forklift truck unloads truckload of 16 pallet boxes, places in temporary storage, and supplies processing line with potatoes at a rate of 60 cwt. per hour	0.567
One man with a forklift truck loads truck with 126 collapsed pallet boxes and supplies processing line with potatoes at a rate of 60 cwt. per hour	0.744

Truck Tie-Up Costs Per Cwt.

Truck tie-up times to load out full loads from temporary storage from the packing line were used to determine an average truck tie-up time when 50 percent of the loads are taken from temporary storage and 50 percent from the packing line.

All truck tie-up times were multiplied by $8 and divided by the cwt. capacity per truckload to arrive at a cost per cwt.

	Dollars per cwt.
Bag method; packing plant; packing rate of 120 cwt. per hour:	
Load out 330-cwt. truckload when 50 percent of the loads are taken from temporary storage and 50 percent from the packing line: Average truck tie-up time, 1.66 hours	0.0402
Load out 330-cwt. truckload from temporary storage: Truck tie-up time, 0.569 hour	0.0138
Bag method; packing plant; packing rate of 240 cwt. per hour:	
Load out 330-cwt. truckload when 50 percent of the loads are taken from temporary storage and 50 percent from the packing line: Average truck tie-up time, 0.972 hour	0.0236
Load out 330-cwt. truckload from temporary storage: Truck tie-up time, 0.569 hour	0.0138
Pallet box method; packing plant; packing rate of 120 cwt. per hour:	
Load out truckload of 16 pallet boxes (320 cwt.) from temporary storage or direct from the packing line when 50 percent of the loads are loaded from temporary storage and 50 percent from the packing line: Average truck tie-up time, 1.505 hours	0.0376
Unload truckload of 126 collapsed boxes: Truck tie-up time, 1.027 hours	0.0033
Total	0.0409
Load out truckload of 16 pallet boxes (320 cwt.) from temporary storage: Truck tie-up time 0.344 hour	0.0086
Unload truckload of 126 collapsed pallet boxes: Truck tie-up time, 1.027 hours	0.0033
Total	0.0119

	Dollars per cwt.
Pallet box method; packing plant; packing rate of 240 cwt. per hour:	
Load out truckload of 16 pallet boxes (320 cwt.) from temporary storage or direct from the packing line when 50 percent of the loads are loaded from temporary storage and 50 percent from the packing line: Average truck tie-up time, 0.867 hour	0.0216
Unload truckload of 126 collapsed pallet boxes: Truck tie-up time, 1.139 hours	0.0038
Total	0.0254
Load out truckload of 16 pallet boxes (320 cwt.) from temporary storage: Truck tie-up time, 0.400 hour	0.0100
Unload truckload of 126 collapsed pallet boxes: Truck tie-up time, 1.189 hours	0.0033
Total	0.0133
Bag method; processing plant; processing rate of 60 cwt. per hour:	
Unload truckload of 330 cwt. and place into temporary storage: Truck tie-up time, 1.387 hours	0.0336
Pallet box method; processing plant; processing rate of 60 cwt. per hour:	
Unload truckload of 16 pallet boxes (320 cwt.) and place into temporary storage: Truck tie-up time, 0.567 hour	0.0142
Load out truckload of 126 collapsed pallet boxes: Truck tie-up time, 0.744 hour	0.0024
Total	0.0166

When the packing line is stopped in the bag method and the crew loads out the bags, a longer working day is necessary to pack the required production and load out the bags at either packing rate. Consequently, overhead costs such as lights and longer hours for management personnel, increase for the bag method. These and any other overhead costs were not considered in this study.

In the box method, the boxes are loaded out during the packing operation. Another advantage of the boxes is that when a truck arrives at the packing-house to be loaded after working hours, one man with a forklift truck can load out 16 boxes in 0.289 hour. Two men would require 1.073 hours to load out 330 bags.

Combined Costs

The combined costs of the cycle from packer through processor are in table 8.

If the processor with an annual volume of 249,600 cwt. owned the pallet boxes instead of the packer, and utilized the boxes with other packers and 726 boxes were required in the cycle, each box would make 17.19 round trips per year. If a box made 60 round trips, the expected life of the box would be 3.49 years. The ownership cost per year would be $3.94 per box, and at 17.19 trips (343.8 cwt.) would amount to $0.0115 per cwt. handled. Therefore, the ownership cost would be reduced from $0.0145 to $0.0115 per cwt., a saving of $0.003 per cwt. handled. The total material cost in the pallet box method would be reduced from $0.0178 to $0.0148 per cwt. The operating cost per cwt. would remain the same.

Table 9 shows the total packer's and processor's costs after the saving has been applied.

If a new bag is used only for one trip instead of three, and the bag has a salvage value of $0.05 at the processing plant, the material cost in the bag method would increase from $0.0568 to $0.1050 per cwt., or an increase of $0.0482 per cwt.

Table 9 shows the total packer's and processor's costs after the increase has been applied.

The total packer's and processor's costs when the processor owns the boxes instead of the packer and the bag is used only for one trip instead of three is shown in table 9.

Other Costs

When shipping potatoes in burlap bags during cold weather, floor racks are required and the load must be kept away from the walls of the truck. Bags tend to shift and may lean against the wall during transportation. Even though the truck is insulated and heated, improper air circulation may occur. Without adequate air circulation, potato temperatures may rise rapidly in top layers close to the heaters while bottom layers get quite cool. In tight trailers where the oxygen supply may be reduced, there is danger of blackheart development when potato temperatures rise much above 70° F. Blackheart often occurs in transit when the temperature in heated vehicles is allowed to go over 90° F. On the other hand, transit temperatures much below 50° may result in excessive accumulation of reducing sugars, which is undesirable in potatoes to be used for processing. 3/

3/ Findlen, H. and Hansen, J. C. Transportation of Late Crop Potatoes for Chipping. Prod. & Tech. Div., Natl. Potato Chip Inst. Proc., 1953:3-6.

Table 8.--Costs of labor, equipment, material, and other items for 2 methods of handling 1 cwt. of potatoes from packer through processor, at 2 packing rates and annual volumes

Cost item	Packing rate, 120 cwt. per hour and annual volume, 96,000 cwt.				Packing rate, 240 cwt. per hour and annual volume, 192,000 cwt.			
	Bag method		Pallet box method		Bag method		Pallet box method	
	50% indirect	100% indirect	50% indirect	100% indirect	50% indirect	100% indirect	50% indirect	100% indirect
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Packer:								
Labor	0.0293	0.0336	0.0250	0.0250	0.0339	0.0336	0.0250	0.0250
Equipment	.0005	.0005	.0138	.0138	.0004	.0004	.0084	.0084
Materials	.0568	.0568	.0178	.0178	.0568	.0568	.0178	.0178
Space	.0117	.0117	.0090	.0090	.0058	.0058	.0045	.0045
Box transport to processor			.0630	.0630			.0630	.0630
Box transport from processor			.0397	.0397			.0397	.0397
Truck tie-up	.0402	.0138	.0409	.0119	.0236	.0138	.0254	.0138
Total	.1385	.1164	.2092	.1802	.1205	.1104	.1838	.1722
Processor: 1/								
Labor	.0377	.0377	.0242	.0242	.0377	.0377	.0242	.0242
Equipment	.0095	.0095	.0073	.0073	.0095	.0095	.0073	.0073
Space	.0186	.0186	.0128	.0128	.0186	.0186	.0128	.0128
Loss for injury	.0096	.0096			.0096	.0096		
Truck tie-up	.0336	.0336	.0166	.0166	.0336	.0336	.0166	.0166
Total	.1090	.1090	.0609	.0609	.1090	.1090	.0609	.0609
Total, packer and processor	.2475	.2254	.2701	.2411	.2295	.2194	.2447	.2331
Difference between bags and boxes	--	--	+.0226	+.0157	--	--	+.0152	+.0137

1/ Based on processing rate of 60 cwt. per hour and an annual volume of 249,600 cwt.

Table 9.--Total cost of packer and processor when processor owns pallet boxes, bags making only one trip, and combination of both

Cost item	Packing rate, 120 cwt. per hour and annual volume, 96,000 cwt.				Packing rate, 240 cwt. per hour and annual volume, 192,000 cwt.			
	Bag method		Pallet box method		Bag method		Pallet box method	
	50% indirect	100% indirect	50% indirect	100% indirect	50% indirect	100% indirect	50% indirect	100% indirect
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Total, packer and processor (processor owns boxes)	0.2475	0.2254	0.2671	0.2381	0.2295	0.2194	0.2417	0.2301
Difference between bags and boxes	--	--	+.0196	+.0127	--	--	+.0122	+.0107
Total, packer and processor (bag, one trip)	.2957	.2736	.2701	.2411	.2777	.2676	.2447	.2331
Difference between bags and boxes	+.0256	+.0325	--	--	+.0330	+.0345	--	--
Total, packer and processor (processor owns boxes - bag, one trip)	.2957	.2736	.2671	.2381	.2777	.2676	.2417	.2301
Difference between bags and boxes	+.0286	+.0355	--	--	+.0360	.0375	--	--

It is assumed, and has been experienced by one potato processor, that the potatoes handled in pallet boxes would maintain a more uniform and proper temperature, consequently reducing losses of potatoes for processing.

Another cost advantage in favor of pallet boxes is quality maintained during storage through better air circulation and temperature control. Potatoes that break down from freezing or from decay entering open wounds tend to shrivel and dry up in pallet boxes, causing no further deterioration. In stacked bags decay tends to spread to other potatoes, causing additional losses and also a messy handling situation.

Due to the lack of precise information, no attempt has been made in this report to assign monetary values to losses incurred because of the above conditions.

CONCLUSIONS

As shown in table 8, costs of labor, equipment, materials, space, transportation of containers (700 miles), losses from injury, and truck tie-up time are less for the bag method than for the pallet box method.

Use of sacks causes increased overhead costs for indirect loading, losses during transit due to adverse temperatures, and quality losses in storage, and so the pallet box method may be more economical.

If bags are used for one trip only and they have a salvage value of $0.05 each, the pallet box method is cheaper than the bag method.

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