SYSTEMS AND COSTS FOR WAREHOUSE RECEIVING AND RETAIL STORE DELIVERY OF CITRUS FRUIT

ARS-NE-95
1978

AGRICULTURAL RESEARCH SERVICE • U.S. DEPARTMENT OF AGRICULTURE

PREFACE

This publication compares the estimated costs of various systems for receiving citrus fruit shipments at the wholesale warehouse and moving the shipments to the retail store. The research conducted in Landover, Md., Baltimore, Md., and Cincinnati, Ohio, is part of a broader program of research to develop systems that will reduce the costs of distributing agricultural products.

B. Russell Robertson and Harold G. Love, extension specialists in agricultural marketing, Cooperative Extension Service, University of Kentucky, provided some of the data for unloading and receiving citrus fruits in the warehouse. Thomas H. Camp, industry economist, Agricultural Research Service, College Station, Tex., assisted in gathering data on the unloading.

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By Joseph P. Anthony, Jr.[1/]

ABSTRACT

The costs of 16 systems for receiving, handling, and delivering citrus fruits (oranges and grapefruits) were developed. The systems were the possible and practicable combinations of 12 cost factors that were developed. The cost factors included handstacked unloading, slipsheeted unloading, palletized unloading, and pallet bin unloading of truck shipments; handstacked unloading and palletized unloading of rail shipments; estimated wholesale losses; handstacked retail delivery; palletized retail delivery, mobile cart retail delivery, pallet bin retail delivery, and estimated retail losses. Models were constructed to reflect costs for handling cartons or carton equivalents of citrus fruits from unloading of the transport vehicle through order selection to delivery at the retail store.

The palletized systems (both palletized unloading and palletized delivery) had the lowest total system costs for trucks at 40.0 cents per carton and railcars at 39.6 cents per carton. The system combining slipsheeted unloading with palletized delivery was a close second for trucks at 40.3 cents per carton and the system combining palletized unloading and mobile cart delivery was a close second for railcars at 40.4 cents per carton.

The system using pallet bins for unloading and delivery had the highest total system costs at 44.8 cents per carton equivalent. Because the receiver owned the bins, the ownership costs of the bin including subsequent handlings and rehandlings were the main source of this system's disadvantage in this comparison. Total distribution system analyses could alter the relative position of pallet bins by including costs for other systems that do not fall in this comparison.

The system costs ranged from a low of 39.6 cents per carton for the totally palletized railcar system to a high of 44.8 cents per carton for the pallet bin system. This total spread of 5.2 cents per carton (or 0.12 cent per pound) between these 16 systems shows how close the results were.
KEYWORDS: Citrus, systems, receiving, handling, delivery, costs.

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INTRODUCTION

The production of citrus fruits--oranges and grapefruits--in the United States is second only to potatoes in value of fresh fruit and vegetable production. In the United States, we consume more fresh citrus fruits per capita than any other single fresh fruit. In 1975 each American consumed an average of 28.9 pounds of fresh citrus fruits, which constituted over 35 percent of the total fresh fruit intake (10).[2/] The United States produces about 33 percent of the world's oranges, 82 percent of the world's grapefruit, and about 38 percent of the world's citrus fruits.

Most fresh citrus fruit shipments in the United States move by truck. Only a small percentage of shipments move by rail from Florida and Texas. A larger percentage, but still not a majority, move by rail from California. This report presents research primarily concerned with receiving truck shipments (but including presently used rail methods) of fresh citrus fruits at the warehouse and subsequent delivery to the retail store. Various systems presently in use and potentially available are evaluated.

This report attempts to measure the labor and equipment requirements and costs for unloading from trucks and railcars unitized (using pallets, slipsheets, and pallet bins) and nonunitized loads and for handling from warehouse to retail store in unitized (pallets and mobile carts) and nonunitized loads. The various component costs are included for various systems that may be applicable. The costs reflect those required at the particular facilities where studies were made. Use of the same systems at different facilities may show slightly different costs.

PROCEDURE

For the purposes of this study, a receiving system is composed of four functions: (1) Unloading transport vehicle (including placing into storage), (2) selecting the retail store order, (3) loading delivery vehicle, and (4) unloading delivery vehicle at retail stores. All labor, materials, and equipment costs related to completing these functions are included as parts of the receiving systems.

Both unitized and nonunitized loading and unloading methods were analyzed to measure labor, materials, and equipment requirements and costs. These costs were measured in man-hours and equipment-hours. The labor man-hour requirements were converted to costs using the 1976 wage rates (Bureau of Labor Statistics) for those job categories. The equipment-hour requirements were converted to costs by using hourly ownership and operating costs developed in appendix table 13.

2/ Underscored figures in parentheses refer to Selected References, p. 17.

To measure the unloading of a transport vehicle with consistency, it was necessary to determine when this operation started and ended. The operation started the moment the first carton or unit of cartons was unloaded from its place in the transport vehicle. The operation ended when the last carton or handling unit was in place in the storage area of the retail store. All unloading studies started and ended at these points.

To determine the least costly citrus fruit distribution system from warehouse selection to retail storage, various warehouses were selected for detailed analyses (7). Cartons were handled on and off delivery vehicles by one of the three following methods:

(1) Handstacking the cartons into the trailer from a four-wheel selector truck or a 48- by 40-inch pallet.

(2) Positioning a loaded pallet into the trailer van.

(3) Positioning a loaded mobile cart into the trailer van.

The costs of delivery, labor, and equipment were obtained from the cooperating firm's records and were averaged to eliminate differences because of geographic locations. Systems, not individual firms, were studied for handling citrus fruits. For this reason, the data presented are averages for the firms using common handling systems.

The costs of cull losses at the wholesale and retail levels were calculated. The cull losses were calculated for metropolitan wholesale and retail outlets (3) as a percentage of the total vehicle load and a current wholesale price per carton for citrus fruits (either oranges or grapefruit, depending upon the model constructed).

Each type of the basic operations was labeled as a factor, and a system was created by combining the alternative component factors into a system to move the fruit from the transport vehicle, through the warehouse, and to the retail store. The total costs of the various systems were compared.

WAREHOUSE RECEIVING

The cost factors for warehouse receiving are analyzed in factors A through G. The Bureau of Labor Statistics Area Wage Survey is used to convert the labor requirements into costs.

Factor A--Handstacked Truck Unloading

In this nonunitized method of unloading, one man removed the cartons of citrus fruits from the stacking pattern in the trailer van and stacked them on a pallet. Using a palletjack, he then moved these palletized units out of the trailer van and onto the dock. A forklift truck carried the palletized units from the dock to the storage area. The labor requirements and costs of unloading 900 cartons are presented in table 1.

Table 1.--Labor requirements and costs for handstacked unloading of 900 cartons from truck shipments of citrus fruits

Labor element	Labor	Cost	Percentage of total cost
	Man-hours	Dollars	
Remove cartons from stacking pattern, stack on pallet, and move palletized unit out of van 1/	1.989	7.78	42.8
Delays in unloading 2/	.439	1.72	9.4
Move loaded pallets from dock to storage (about 150 feet) 3/	.693	3.87	21.2
Wait for next pallet load 3/	.266	1.48	8.1
Supervise unloading 3/	.606	3.38	18.5
Total	3.993	18.23	100.0

1/ Average wage rate is $3.91 per hour for laborers (11). Wage rate does not include cost of fringe benefits.

2/ Delays include personal time plus work stoppage caused by handling equipment.

3/ Average wage rate is $5.58 per hour for forklift operators (11); supervisors were included in this wage rate. Wage rate does not include cost of fringe benefits. This wage rate will be used in all subsequent tables on truck and railcar unloading.

The forklift truck moved pallets of cartons from three trucks which were unloaded at the same time. A dock foreman supervised operations of the entire loading dock. Equipment inputs per hour per truckload averaged 0.924 equipment-hour for the forklift truck, 0.716 equipment-hour for the palletjack, and 2.342 equipment-hours for each pallet (36 were used) and the dockplate. At an ownership and operating cost of $4.32 per equipment-hour for the forklift truck and its battery and charger, $1.27 for the palletjack, $0.18 for the dockplate, and $0.0024 for each pallet (appendix table 13), the equipment costs were $5.53. The total labor and equipment handling costs of unloading one trailer van load of 900 cartons were $23.76, or $0.026 per carton of citrus fruits.

Factor B--Slipsheeted Truck Unloading

In this method of unitized handling, a modified forklift truck with a special push-pull attachment grasped a 4-inch extension of the slipsheet referred to as the "lip" and pulled the slipsheeted unit onto the tines of the modified forklift truck. This attachment also included a sideshifting feature that enabled the driver to position the unit with less maneuvering of the forklift truck. This modified forklift truck moved the slipsheeted unit out of the vehicle and onto the dock where a man placed and positioned the unit on a pallet. A conventional forklift truck then picking up this pallet moved into the storage area, while the modified forklift truck returned to the trailer van for removal of the next slipsheeted unit. Another man was used to place and position the pallets on the dock to help the conventional forklift truck operator. A dock foreman supervised the unloading operation. The labor requirements and costs to unload one van with 18 slipsheeted units of 48 cartons each are presented in table 2.

One modified forklift truck with the push-pull attachment was used for each trailer being unloaded. A conventional forklift truck moved cartons of citrus fruits into the storage area from more than one trailer van.

Equipment inputs per hour per truckload averaged 0.610 equipment-hour for the conventional forklift truck, 1.010 for the modified forklift truck, and 1.075 for each pallet and the dockplate. At an ownership and operating cost of $4.32 per equipment-hour for the conventional forklift truck and its battery and charger, $5.18 for the modified forklift truck, $0.18 for the dockplate, and $0.0024 for each pallet (appendix table 13), the equipment costs for unloading one van were $8.11. The total labor and equipment handling costs of unloading one trailer van with 18 slipsheeted units each containing 48 cartons were $19.90, or $0.023 per carton of citrus fruits.

Factor C--Palletized Truck Unloading

In this method of unitized unloading, a forklift truck removed the palletized units from the trailer van and moved them to a storage area. A dock foreman supervised the entire unloading operation. The labor requirements and costs to unload one trailer van with 18 palletized units each containing 48 cartons are presented in table 3.

A forklift truck unloaded one trailer van at a time. The shipping pallets which were provided by the shipper at his expense were expendable. As part of his job a dock foreman supervised the entire unloading operation.

The equipment inputs per hour per truckload averaged 1.549 equipment-hours. At an ownership and operating cost of $4.50 per equipment-hour for the forklift truck and its battery and charger and the dockplate (appendix table 13), the equipment costs were $6.97. The total labor and equipment handling costs of unloading one trailer van with 18 palletized units each containing 48 cartons were $16.96, or $0.020 per carton of citrus fruit.

Table 2.--Labor requirements and costs for unloading 1 trailer van with 18 slipsheeted units of 48 cartons each in a truck shipment of citrus fruits

Labor element	Labor	Cost	Percentage of total cost
	Man-hours	Dollars	
Manually place and position pallets on the dock 1/	0.340	1.33	11.3
Wait for next slipsheeted unit 1/	.124	.48	4.1
Pick up, move from vehicle, and place slipsheeted units on pallets on dock 2/	.760	4.24	36.1
Delays in picking up unit 2/, 3/	.198	1.10	9.3
Pick up palletized unit and move to storage 2/	.503	2.81	23.8
Delays in picking up palletized units 2/, 3/	.088	.49	4.1
Supervise unloading 2/	.240	1.34	11.3
Total	2.253	11.79	100.0

1/ See table 1, footnote 1.
2/ See table 1, footnote 3.
3/ See table 1, footnote 2.

Table 3.--Labor requirements and costs for palletized unloading of 864 cartons in 18 units from a truck shipment of citrus fruits

Labor element	Labor	Cost	Percentage of total cost
	Man-hours	Dollars	
Pick up, move from trailer van, and place palletized units in storage 1/	1.263	7.05	70.6
Delays in picking up units 1/	.286	1.60	16.0
Supervise unloading 1/	.240	1.34	13.4
Total	1.789	9.99	100.0

1/ See table 1, footnote 3.

Factor D--Pallet Bin Truck Unloading

In this method of unitized unloading, a forklift truck carried the pallet bins from the truck trailer van to the storage area. The only labor required was a forklift truck operator and a dock foreman. The labor requirements and costs to unload one trailer van with 36 pallet bins on pallets are presented in table 4.

Table 4.--Labor requirements and costs for unloading 36 pallet bins from a truck shipment of citrus fruits

Labor element	Labor	Cost	Percentage of total cost
	Man-hours 1/	Dollars	
Move units out of vehicle and into storage 2/	0.752	4.20	62.2
Delays in going to pick up the units 2/	.271	1.51	22.3
Supervise unloading 2/	.188	1.05	15.5
Total	1.211	6.76	100.0

1/ Based on 36 pallet bins and pallets with a total payload weight of approximately 39,600 pounds and a net weight of approximately 36,700 pounds, or 874 carton equivalents.

2/ See table 1, footnote 3.

The bins were corrugated fiberboard, had a three-trip life, and were reused for citrus fruit shipments. The bins were kept within the system and were assumed to be owned and returned to origin by the receiver, and the per bin per trip cost was shared evenly by shipper and receiver. The pallets and slipsheets and other cost factors were supplied by the shipper. The per trip cost consisting of a cost for the bin includes initial cost plus freight in and return freight, a cost for the pallet base that has a much longer reuse life than the fiberboard components, and a cost for reinforced tape to seal the flaps on the bins. The total cost per bin per trip is approximately $3.50 or $126.00 per truckload and,if evenly divided between shipper and receiver, is reduced to $58.00, or $0.066 per carton equivalent.

A forklift truck unloaded one trailer van at a time. As part of his job, the dock foreman supervised the unloading operation. The equipment input per hour per truckload averaged 0.950 equipment-hour. At an ownership and operating cost of $4.50 per equipment-hour for the forklift truck and its battery and charger and the dockplate (appendix table 13), the equipment costs were $4.28. The total labor, materials, and equipment costs of unloading one trailer van with 36 pallet bins (874 cartons) were $69.04, or $0.079 per carton equivalent.

Factor E--Handstacked Railcar Unloading

In this nonunitized method of unloading, two men removed the cartons from the stacking pattern in the railcar and stacked them on a pallet. A forklift truck then carried the palletized unit out of the railcar and into the storage area. A dock foreman supervised more than one unloading at any one time. The labor requirements and costs of unloading 1,554 cartons with a two-man crew are presented in table 5.

Table 5.--Labor requirements and costs for handstacked unloading of 1,554 cartons in palletized units from a railcar shipment of citrus fruits

Labor element	Labor	Cost	Percentage of total cost
	Man-hours 1/	Dollars	
Set up, clean up, and position pallets for loading 2/	0.601	2.35	7.0
Remove cartons from stacking pattern and stack on pallets 2/	4.043	15.81	46.9
Move loaded pallets from railcar to storage (approximately 100 feet) 3/	1.236	6.90	20.5
Wait for next pallet load 3/	.969	5.41	16.1
Supervise unloading 4/	.572	3.19	9.5
Total	7.421	33.66	100.0

1/ Bogardus and Ferris (2).
2/ See table 1, footnote 1.
3/ See table 1, footnote 3.
4/ Calculated at 1/4 of elapsed time.

The equipment inputs per hour per railcar load averaged 2.289 equipment-hours for the forklift truck, dockplate, and each pallet (65 were used).

At an ownership and operating cost of $4.32 per equipment-hour for the forklift truck and its battery and charger, $0.0024 for each pallet, and $0.18 for the dockplate (appendix table 13), the equipment costs were $10.67. The total labor and equipment costs of unloading one railcar were $44.33, or $0.029 per carton of citrus fruits.

Factor F--Palletized Railcar Unloading

In this method of unitized unloading, one man with a palletjack removed the palletized units one at a time from the railcar and placed them on the dock. Because these pallets are smaller (42 by 35 inches) than the standard pallets (48 by 40 inches) used in the receiver's pallet racks, a forklift truck placed them on top of standard pallets for internal handling. The smaller shipping pallets were provided by the shipper at his expense. A dock foreman supervised the entire unloading operation. The labor requirements and costs to unload one railcar (1,260 cartons in 36 palletized units) are presented in table 6.

Table 6.--Labor requirements and costs to unload 36 palletized units (1,260 cartons) from a railcar shipment of citrus fruits

Labor element	Labor	Cost	Percentage of total cost
	Man-hours	Dollars	
Pick up and move from railcar 1/--------	1.125	6.28	43.8
Place palletized units on standard pallets and move to storage 1/--------	.640	3.57	24.9
Delays in picking up units 1/----------	.367	2.05	14.3
Supervise unloading 1/----------	.438	2.44	17.0
Total----------	2.570	14.34	100.0

1/ See table 1, footnote 3.

The equipment inputs per carload averaged 1.383 equipment-hours for the palletjack, 0.749 for the forklift truck, 1.750 for each pallet and the dockplate. At an ownership and operating cost of $4.32 per equipment-hour for the forklift truck and its battery and charger, $1.27 for the palletjack, $0.18 per for the dockplate, and $0.0024 for each pallet (appendix table 13), the equipment costs were $5.47. The total labor and equipment costs of unloading one railcar (1,260 cartons in 36 palletized units) were $19.81, or $0.016 per carton of citrus fruits.

Factor G--Wholesale Losses

Cull losses were found for Valencia oranges from Florida in wholesale outlets in the New York City area. Decayed fruits comprised most of the citrus culled in the wholesale samples. Parasitic diseases spoiled 0.9 percent of all fruits examined, mechanical injury spoiled 0.3 percent, and nonparasitic disorders spoiled 0.1 percent. Thus, 1.3 percent of the citrus fruits in wholesale samples were lost (3).

By applying this loss figure as a percentage of the vehicle load for the cost factors A through F to a current market value for a carton of citrus fruit, the cost of lost citrus fruit per vehicle and per carton of citrus fruit that can be shipped to the retail store is calculated in table 7. A cost factor for wholesale losses was included because these losses are a reality and deserve consideration even though data did not show significant loss differences between the systems studied.

Table 7.--Cost of wholesale citrus fruit losses and loss per carton shipped to retail store

Cost factor	Cartons per vehicle	Cartons lost 1/	Cost of loss 2/	Cost per carton to retail 3/
	Number	Number	Dollars	Dollars
A----------	900	11.7	67.28	0.076
B----------	864	11.2	64.40	.076
C----------	864	11.2	64.40	.076
D----------	874	11.4	65.55	.076
E----------	1,554	20.2	116.15	.076
F----------	1,260	16.4	94.30	.076

1/ Calculated using 1.3 percent wholesale loss factor.
2/ Based on wholesale value of $5.75 per carton of citrus fruits.
3/ $\frac{\text{Cost of loss}}{\text{Cartons shipped less cartons lost}}$ = loss per carton to retail.

For all of the unloading cost factors, the wholesale cull losses added $0.076 to the cost of each carton equivalent that could be shipped to the retail stores.

WAREHOUSE SHIPPING

Before delivery to the retail store, the mixed produce that was shipped to and unloaded at the warehouse (factors A through F) must be selected and assembled into an order for an individual store. Also, the storage space must be restocked to facilitate future orders. The delivery vehicle must be loaded and moved from the warehouse to the retail store for unloading. The costs of these functions are found in factors H through K.

Factor H--Handstacked Retail Delivery

In this method of delivery to retail stores, one man selected the cartons of citrus fruits and handstacked them on a pallet on a 4-wheel selector truck. A series of these selector trucks were pulled by an electric tugger and taken to the delivery vehicle. At the retail store two men unloaded the cartons using a roller conveyor, a palletjack, and pallets. The labor requirements to select, load, deliver, and unload one trailer (1,000 mixed-produce cartons of which 150 cartons were citrus fruits) are presented in table 8.

Table 8.--Labor requirements and costs to select, load, deliver, and unload handstacked cartons of citrus fruits from warehouse to retail store as a part of a mixed-produce truckload 1/

Labor element	Time 2/ per--		Cost 4/ per--	
	1,000 cartons of mixed produce 3/	150 cartons of citrus fruits	150 cartons of citrus fruits	1 carton of citrus fruits
	Man-hours	Man-hours	Dollars	Dollars
Select cartons of produce (long line) and stack on selector truck	5.067	0.760	3.80	0.025
Stock replenishment	.730	.110	.55	.004
Load cartons into delivery vehicle	2.583	.388	1.94	.013
Deliver to store and return	3.200	.480	2.40	.016
Unload at store	7.880	1.182	5.91	.039
Total	19.460	2.920	14.60	.097

1/ Truckload consisted of 1,000 cartons of mixed produce of which 150 cartons were citrus fruits.

2/ Total elemental time plus 15 percent personal and fatigue allowance.

3/ Shaffer and Steckler (7).

4/ Labor costs based on average wage rate of $5.00 per hour.

The equipment-hour inputs per citrus fruit load averaged 0.760 for the electric tugger, 2.280 for the selector truck, 4.592 for the pallets, and 1.570 for the roller conveyor. At an ownership and operating cost of $1.27 per equipment-hour for the electric tugger and its battery and charger which are the same as for the palletjack, $0.05 for the selector truck, $0.0024 for each pallet, and $0.19 for the roller conveyors (appendix table 13), the equipment costs for handling equipment were $1.43, or $0.010 per carton.

The transport vehicle made an 80-mile round trip during its 8-hour delivery trip. With ownership costs of $3.25 per hour for the tractor and trailer with an elevator and operating costs of $1.57 per mile, total daily costs to deliver the truckload of produce were $151.60, or $0.152 per carton.

The total labor and equipment costs of handstacked delivery of 150 cartons of citrus fruits to the retail store were $0.259 per carton.

Factor I--Palletized Retail Delivery

In this method of delivery to retail stores, the cartons of citrus fruits were selected and stacked onto a pallet with other fresh fruits and vegetables which were loaded into the 40-foot refrigerated trailer van of the delivery vehicle. After delivery to the retail stores, one man unloaded the palletized units from the trailer van with a palletjack and placed the units in storage at the store. The labor requirements to select, load, deliver, and unload one trailer (1,000 mixed-produce cartons of which 150 cartons were citrus fruits) are shown in table 9.

Table 9.--Labor requirements and costs to select, load, deliver, and unload palletized cartons of citrus fruits from warehouse to retail store as a part of a mixed-produce truckload 1/

Labor element	Time 2/ per--		Cost 4/ per--	
	1,000 cartons of mixed produce 3/	150 cartons of citrus fruits	150 cartons of citrus fruits	1 carton of citrus fruits
	Man-hours	Man-hours	Dollars	Dollars
Select carton of produce (long line) and stack on pallet	4.867	0.730	3.65	0.024
Stock replenishment	.730	.110	.55	.004
Load palletized units into vehicle	.617	.093	.46	.003
Deliver to store and return	3.390	.509	2.55	.017
Unload at store	2.650	.398	1.99	.013
Total	12.254	1.840	9.20	.061

1/ Truckload consisted of 1,000 cartons of mixed produce of which 150 cartons were citrus fruits.

2/ Total elemental time plus 15 percent personal and fatigue allowance.

3/ Shaffer and Steckler (7).

4/ Labor costs based on average wage rate of $5.00 per hour.

The palletjack is used for all handling. The equipment inputs per citrus-fruit load averaged 1.221 equipment-hours for the palletjack, 11.524 for the pallets (three), and 0.491 for the dockplate. At an ownership and operating cost of $1.27 per equipment-hour for the palletjack and its battery and charger, $0.0024 for each pallet, and $0.18 for the dockplate (appendix table 13), the costs for handling equipment were $1.75, or $0.012 per carton.

The transport vehicle made an 80-mile round trip during its 8-hour delivery trip. With ownership costs of $3.53 per hour for the tractor and trailer and with elevator and operating costs of $1.57 per mile, total daily cost to deliver the truckload of produce was $153.84, or $0.154 per carton of citrus fruit. The total equipment costs for handling and transporting were $0.166 per carton.

The total labor and equipment costs of palletized delivery of 150 cartons of citrus fruits to the retail store were $0.227 per carton.

Factor J--Mobile Cart Retail Delivery

In this method of delivery to retail stores, the cartons of citrus fruits were selected and stacked on a mobile cart. A series of these filled mobile carts were pulled by an electric tugger and taken to the delivery vehicle. One man then moved the mobile carts into the delivery vehicle. Another man unloaded the carts at the retail store using the elevator-tailgate on the trailer. The labor requirements to select, load, deliver, and unload one trailer (1,000 mixed-produce cartons of which 150 cartons were citrus fruits) are in table 10.

Table 10.--Labor requirements and costs to select, load, deliver, and unload cartons of citrus fruits on mobile carts from warehouse to retail store as a part of a mixed-produce truckload 1/

Labor element	Time 2/ per--		Cost 4/ per--	
	1,000 cartons of mixed produce 3/	150 cartons of citrus fruits	150 cartons of citrus fruits	1 carton of citrus fruits
	Man-hours	Man-hours	Dollars	Dollars
Select cartons of produce and stack on mobile carts--	5.883	0.882	4.41	0.029
Stock replenishment----------	.730	.110	.55	.004
Load carts into delivery vehicle--------------------	1.105	.166	.83	.006
Deliver to store and return--	3.790	.569	2.85	.019
Unload at store--------------	1.760	.264	1.32	.009
Total-------------------	13.268	1.991	9.96	.067

1/ Truckload consisted of 1,000 cartons of mixed produce of which 150 cartons were citrus fruits.
2/ Total elemental time plus 15 percent personal and fatigue allowance.
3/ Shaffer and Steckler (7).
4/ Labor cost based on an average wage rate of $5.00 per hour.

The equipment-hour inputs per citrus-fruit load averaged 0.882 for the electric tugger and 8.000 for each mobile cart. At an ownership and operating cost of $1.27 per equipment-hour for the electric tugger and its battery and charger which are the same as for the palletjack and $0.03 for each mobile cart (appendix table 13), the equipment costs for handling were $2.08, or $0.014 per carton.

The transport vehicle made an 80-mile round trip during its 8-hour delivery trip. With ownership and operating costs of $3.53 per hour for the tractor and trailer with an elevator tailgate and operating costs of $1.57 per mile, total costs to deliver the truckload of produce were $153.84, or $0.154 per carton. The total equipment costs for handling and transporting were $0.168 per carton.

The total labor and equipment costs of mobile delivery of 150 cartons of citrus fruits to the retail store were $0.235 per carton.

Factor K--Pallet Bin Retail Delivery

In this method of delivery to retail stores, the pallet bins of citrus fruits were moved from the pallet racks and loaded into the 40-foot refrigerated trailer van of the delivery vehicle. After delivery to the retail stores one man unloaded the pallet bins using a palletjack and placed the pallet bins in storage at the store. The labor requirements to move, load, deliver, and unload one trailer (1,000 mixed-produce cartons of which 150 are carton equivalents of citrus fruits) are in table 11.

The palletjack is used for all handling. The equipment inputs per citrus load averaged 1.221 equipment-hour for the palletjack and 0.491 for the dockplate. At an ownership and operating cost of $1.27 per equipment-hour for the palletjack and its battery and charger and $0.18 for the dockplate (appendix table 13), the equipment costs for handling equipment were $1.64, or $0.011 per carton.

The transport vehicle made an 80-mile round trip during its 8-hour delivery trip. With ownership costs of $3.53 per hour for the tractor and trailer with an elevator and operating costs of $1.57 per mile, total daily cost to deliver the truckload of produce was $153.84, or $0.154 per carton. The total equipment costs for handling and transporting were $0.165 per carton.

The total labor and equipment costs for pallet bin delivery of 150 cartons of fruit to the retail stores were $0.216 per carton.

Factor L--Retail Losses

Losses at cooperating retail stores during a 3-year study closely followed the results obtained in wholesale studies. Decay was again the leading cause of spoilage at retail stores. Losses from parasitic diseases came to 0.9 percent; from mechanical damage, 0.2 percent; and from nonparasitic disorders, 0.1 percent. Culls from all causes totaled 1.2 percent at retail.

Table 11.--Labor requirements and costs to move, load, deliver, and unload pallet bins of citrus fruits from warehouse to retail store as a part of a mixed-produce truckload 1/

Labor element	Time 2/ per--		Cost 3/ per--	
	1,000 cartons of mixed produce	150 cartons of citrus fruits	150 cartons of citrus fruits	1 carton of citrus fruits
	Man-hours	Man-hours	Dollars	Dollars
Select pallet bins from racks and assemble for loading 4/	0.594	0.099	0.46	0.003
Stock replenishment 5/	.730	.110	.55	.004
Load pallet bins into vehicle 5/	.617	.093	.46	.003
Deliver to store and return 5/	3.390	.509	2.55	.017
Unload at store 5/	2.650	.398	1.99	.013
Total	7.981	1.209	6.01	.040

1/ Truckload consisted of 1,000 cartons of mixed produce of which 150 are citrus carton equivalents.
2/ Total elemental time plus 15 percent personal and fatigue allowance.
3/ Labor costs based on average wage rate of $5.00 per hour.
4/ Anthony and Camp (1).
5/ Shaffer and Steckler (7).

These loss figures were applied as a percent of the cartons of citrus fruits delivered to various retail stores in a truckload at a current market value per carton that could be marketed. Using the 1.2 percent loss factor, 1.8 cartons of each 150 cartons delivered were culled at the retail store. With a value at the retail store of $6.30 per carton, the total retail loss was $11.34, or $0.077 per carton of citrus fruits available for sale.

COMPARISON OF TOTAL SYSTEM COSTS

From the cost factors studied, a total of 16 possible compatible systems can be constructed. Those systems are detailed in table 12. The total system costs per carton ranged from a high of 44.8 cents for the pallet bin truck system to a low of 39.6 cents for totally palletized railcar system.

Comparison by type of delivery with the unloading method kept constant shows that in every case the palletized systems are the least expensive, the mobile cart systems are next, and the handstacked systems are the most expensive. For example, in the systems with handstacked unloading of trucks, the total system costs for system 1 (handstacked unloading--palletized delivery)

Table 12.--Summary of cost factor components of potential systems for moving cartons of citrus fruits from warehouse to retail store

System	=	Cost factor components	=	Cost per carton of citrus fruits[1/] Unloading	+	Wholesale loss	+	Delivery	+	Retail loss	=	Total	Type of handling[2/] Unloading	Delivery
				Dollars		Dollars		Dollars		Dollars		Dollars		
1	=	A+G + H+L	=	0.026	+	0.076	+	0.227	+	0.077	=	0.406	HS	P
2	=	A+G + I+L	=	.026	+	.076	+	.259	+	.077	=	.438	HS	HS
3	=	A+G + J+L	=	.026	+	.076	+	.235	+	.077	=	.414	HS	MC
4	=	B+G + H+L	=	.023	+	.076	+	.227	+	.077	=	.403	SS	P
5	=	B+G + I+L	=	.023	+	.076	+	.259	+	.077	=	.435	SS	HS
6	=	B+G + J+L	=	.023	+	.076	+	.235	+	.077	=	.411	SS	MC
7	=	C+G + H+L	=	.020	+	.076	+	.227	+	.077	=	.400	P	P
8	=	C+G + I+L	=	.020	+	.076	+	.259	+	.077	=	.432	P	HS
9	=	C+G + J+L	=	.020	+	.076	+	.235	+	.077	=	.408	P	MC
10	=	D+G + K+L	=	.079	+	.076	+	.216	+	.077	=	.448	PB	PB
11	=	E+G + H+L	=	.029	+	.076	+	.227	+	.077	=	.409	HS	P
12	=	E+G + I+L	=	.029	+	.076	+	.259	+	.077	=	.441	HS	HS
13	=	E+G + J+L	=	.029	+	.076	+	.235	+	.077	=	.417	HS	MC
14	=	F+G + H+L	=	.016	+	.076	+	.227	+	.077	=	.396	P	P
15	=	F+G + I+L	=	.016	+	.076	+	.259	+	.077	=	.428	P	HS
16	=	F+G + J+L	=	.016	+	.076	+	.235	+	.077	=	.404	P	MC

1/ Excludes all overhead and selling costs.
2/ HS = handstacked, SS = slipsheeted, P = palletized, PB = pallet bin, MC = mobile carts.

were 40.6 cents per carton, for system 2 (handstacked unloading--handstacked delivery) 43.8 cents, and for system 3 (handstacked unloading--mobile cart delivery) 41.4 cents. This relationship remains relatively constant in every one of the similar comparisons.

Comparisons by method of unloading with delivery kept constant has the same results as the converse comparison above. The handstacked unloading systems are most expensive, the palletized are the least expensive, and the slipsheeted are intermediate in cost.

The handling systems using palletized delivery offer savings of 3.2 cents per citrus carton over those using handstacked delivery and 0.8 cent per citrus carton over those using mobile cart delivery.

Totally palletized and partly palletized systems were consistently less expensive than the other systems compared. Lower unloading and delivery costs were the main contributing factors.

CONCLUSIONS

The following conclusions can be drawn from this study:

- Totally palletized systems can offer the lowest total cost whereas the totally handstacked systems can offer the highest total cost systems.

- The use of palletized methods in part of a system can offer savings no matter what methods are used for the rest of the system.

- Palletized unloading and delivery seem to offer potential savings that should be explored by any receiver and distributor.

- Using the total cartons of citrus fruits shipped as a basis, the least cost system could offer potential savings of about $10 million annually when compared with the highest cost system.

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APPENDIX

Table 13.--Development of hourly ownership and operating costs

Operation and equipment	Cost	Estimated life	Ownership costs			
			Annual depreciation 1/	Insurance and taxes 2/	Interest	Total ownership cost
	Dollars	Years	Dollars	Dollars	Dollars	Dollars
Unloading (TSP vehicle) 5,000 lb electric 6/:						
Forklift truck triple mast	18,300	7/7	2,614.29	915.00	732.00	4,261.29
Battery 48 kWh	2,900	3	966.67	145.00	116.00	1,227.67
Charger	850	10	85.00	42.50	34.00	161.50
Palletjack 3,000 lb electric 6/	3,000	7/7	428.57	150.00	120.00	698.57
Battery 12.58 kWh	2,200	3	733.33	110.00	88.00	931.33
Charger	850	10	85.00	42.50	34.00	161.50
Push-pull attachment 6/	5,000	7/7	714.29	250.00	200.00	1,164.29
Dockplate	500	4	125.00	25.00	20.00	170.00
Pallet GMAC 48 X 40	6	8/3	2.00	.24	.18	2.42
Warehouse:						
4-wheel selector truck	500	10	50.00	25.00	20.00	95.00
Pallet GMAC 48 X 40	6	8/3	2.00	.24	.18	2.42
Electric tugger	4,000	7	571.43	200.00	160.00	931.43
Mobile cart	200	5	40.00	10.00	8.00	58.00
Roller conveyors 11/	600	5	120.00	30.00	24.00	174.00
Delivery:						
Tractor	25,000	6	4,166.67	1,250.00	1,000.00	6,416.67
Refrigerator trailer	14,000	8	1,750.00	700.00	560.00	3,010.00
Refrigerator trailer with elevator	17,500	8	2,187.50	875.00	700.00	3,762.50

1/ Straight-line depreciation.
2/ Insurance and taxes at 5 percent of cost.
3/ Interest at 4 percent of cost or 8 percent of undepreciated balance.
4/ Power at 5 percent of cost for gas-powered equipment; electric power based on a rate of $0.04 per kWh.
5/ Maintenance at 2.5 percent of cost.
6/ Source: Handling Equipment Sales Co., Inc., Landover, Md. 1977.
7/ Clark Equipment Co., obsolescence and replacement survey of lift truck usage.
8/ Stroble (8).

for equipment inputs for handling systems for citrus fruits

Operating costs			Total ownership and operation costs	Total operation	Ownership and operating cost per equipment-hour
Power 4/	Maintenance 5/	Total operation cost			
Dollars	Dollars	Dollars	Dollars	Hours	Dollars
---	457.50	457.50	4,718.79	7/1,500	3.1459
---	---	---	1,227.67	2,250	.5456
9/288.00	21.25	309.25	470.75	750	.6277
---	75.00	75.00	773.57	7/1,500	.5157
---	---	---	931.33	2,250	.4139
9/ 75.48	21.25	96.73	258.23	750	.3443
---	125.00	125.00	1,289.29	7/1,500	.8595
---	12.50	12.50	182.50	1,000	.1825
---	10/ 1.23	1.23	3.65	1,500	.0024
---	12.50	12.50	107.50	2,000	.0537
---	10/ 1.23	1.23	3.65	1,500	.0024
---	100.00	100.00	1,031.43	2,000	.5157
---	5.00	5.00	63.00	2,000	.0315
---	15.00	15.00	189.00	1,000	.1890
		1.57/mile	6,416.67	3,000	2.1389
			3,010.00	2,700	1.1148
			3,762.50	2,700	1.3935

9/ Power costs for battery charging of electric-powered vehicles are computed from manufacturer's specifications. The formula used is as follows: battery capacity (kWh) X discharge rate per hour (10 percent of battery capacity) X 2 (50 percent charging efficiency) X cost of electricity ($0.04 per kWh) X hours of use per year (750)=power costs.

10/ Strobel and Wallin (9) found $0.88 per pallet for repairs. Using a 40 percent factor to bring this cost to 1977 gives a cost of $1.23. 3 sections 9 feet by 12 inches at $200 per section = $600.

11/ Operating costs per mile to be used.

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