Apples-Storage

ECONOMICS INFORMATION REPORT

COSTS OF STORING NORTH CAROLINA APPLES

GENE A. MATHIA

North Carolina.

ECONOMICS INFORMATION REPORT NO. 5
DEPARTMENT OF ECONOMICS
N. C. STATE UNIVERSITY AT RALEIGH
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TABLE OF CONTENTS

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Situation

Limited quantities of North Carolina apples are stored at harvest for sales throughout the marketing season. Only 825,000 bushels were in storage on November 1, 1965, and almost 500,000 bushels on the same date in 1966 (see Appendix Table 1). The quantity stored in November 1966 represented only 18 percent of the total North Carolina crop and as usual was only for temporary storage.[1] Only 495,000 bushels of the 1965 crop and 171,000 bushels of the 1966 crop remained in storage on December 1 and very few apples are stored after April 1 in any year. The small proportion of the crop stored and the short holding period occurred because most of the storage units presently located in North Carolina are small cooling or holding rooms and the length of time apples can be stored without affecting the quality of the apples is relatively short.

Large quantities of apples are stored in several of the northeastern states, Michigan and Washington.[2] November holdings for 1966 in the United States were 63.5 million bushels or 51 percent of total U. S. production and 33 percent more than comparable North Carolina holdings (Appendix Table 2). The seasonal pattern also differed with holdings gradually declining until only 4.6 million bushels remained in storage on June 1, 1966. Monthly holdings have gradually increased from 1956 to 1966.

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[1] U. S. Department of Agriculture, Crop Production, 1966 Annual Summary, CR-PR2-1(66), Washington, D. C., 1966.

[2] U. S. Department of Agriculture, The Fruit Situation, Economic Research Service, TFS-158, Washington, D. C., January 1966, p. 7.

A large part of this increase can be accounted for by the rapid growth of controlled atmosphere storages. November holdings under controlled atmosphere conditions increased from 1.0 million bushels in 1956 to 13.0 million bushels in 1966 (Appendix Table 3). The quantity stored under controlled atmosphere conditions declined gradually until the first of March but this has not been the case for apples in regular storage (Figure 1). Regular storage holdings declined rapidly during the months of October, November, December, January and February.

The two basic methods of storing apples already have been mentioned. The most common method is by regular low temperature refrigeration. This type of storage maintains satisfactory marketing quality of apples for a relatively short time, i.e., storage of 150 days is considered a normal storage period. Many factors affect the length of the storage period such as the maturity of the apples when placed in storage and the length of time between harvesting and lowering the temperature of the apple to near freezing.

The controlled atmosphere method of storing apples has developed commercially since 1940.[3] This method of storage retards the ripening and deterioration of fruit by regulating temperature and the level of oxygen and/or carbon dioxide in the atmosphere. Research in several states indicates that the quality of the fruit can be maintained for a much longer period if the atmosphere contains oxygen levels of less than 5 percent, carbon dioxide levels of 1 to 7 percent and the remainder made up of nitrogen. Air usually contains 78 percent nitrogen, 20.8 percent oxygen and .03 percent carbon dioxide.

Problem

Anticipated increases in apple production in North Carolina have focused attention on the prospects of profitable storage. North Carolina apple production has previously been projected for 1974 at a high of 6.8

[3] For a discussion of the development of controlled atmosphere storage of fruit, see Dana G. Dalrymple, The Development of Controlled Atmosphere Storage of Fruit, Division of Marketing and Utilization Sciences, Federal Extension Service, U. S. Department of Agriculture, Washington, D. C., 1967.

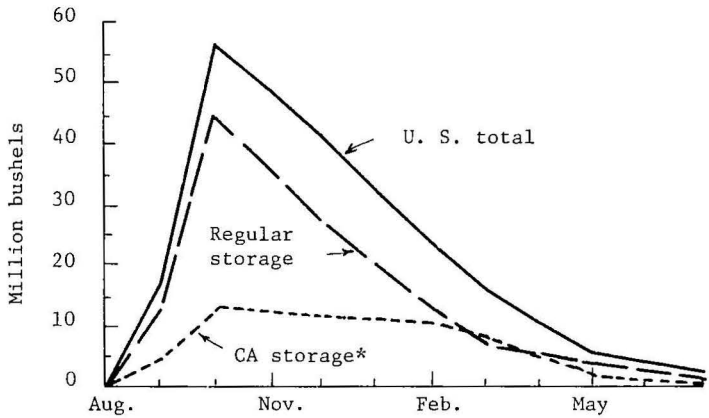

Figure 1. Apples in cold storage, 1964-65[a]

*Controlled atmosphere storage.

[a]Source: U. S. Department of Agriculture, Fruit Situation, Economic Research Service, TFS-158, January 1966, p. 1.

million bushels.[4] This would represent 170 percent more production than that produced in recent years. The prospects of efficiently marketing N. C. apples at relatively favorable prices may be enhanced if larger volumes of apples are stored for later sales. The question is being evaluated in a companion study.

Little information on the costs of storing N. C. apples by the two storage methods is currently available to investors interested in constructing storage facilities. A study of storing apples by these two methods was made in New York state in 1962, but prices of labor, buildings and equipment have increased and the technology of controlled atmosphere operations has changed rapidly since then.[5]

A study of the efficiency of labor utilization in handling apples was made in Washington state in 1953 by the U. S. Department of Agriculture.[6] In many cases, the labor requirements for handling fruit in the several stages have not changed significantly but the prices of labor and equipment have increased very rapidly. Thus, there is need at this point to compare costs for both methods of storing apples under North Carolina conditions and current prices. The scarcity of labor in the apple producing area of North Carolina brought requests from interested packers who are considering the storage alternative to evaluate the profitability of substituting additional capital in the form of palletized operations for the more labor intensive, non-palletized method.

The purpose of this study is to provide cost estimates for selected sizes of regular and controlled atmosphere storage operations handled as separate but an integral part of the packing operations. The results of the study should be useful to potential investors and particularly those

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[4] E. C. Pasour, Jr. and Gene A. Mathia, Estimates of 1974 Apple Production in North Carolina--A Comparison of Three Predictive Procedures, Economic Research Report 1, Department of Economics, North Carolina State University, Raleigh, January 1967.

[5] John C. Thompson, Jr., Apple Storage Costs in New York State, A. E. Research Report 87, Cornell University, Ithaca, New York, 1962.

[6] Earl W. Carlsen and Joseph F. Herrick, Jr., Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses, Marketing Research Report No. 49, U. S. Department of Agriculture, Washington, D. C., 1953.

apple packers in western North Carolina who currently pack large volumes of apples and desire greater flexibility in their sales program.

Procedure

The economic-engineering method was used to evaluate the costs of storing apples in North Carolina.[7] Four sizes of operations were selected to represent typical sizes of operations for western North Carolina. These sizes measured at full capacity were 10, 20, 40 and 80 thousand packed cartons of apples. Estimates of costs for size of operation other than but within these size limits could be derived easily by making appropriate adjustments. Costs for regular storage were compared with the costs of controlled atmosphere storage units of the same size. In addition, costs for each type of storage were estimated for various volumes to determine how size of operation affected average unit costs. Palletized and non-palletized methods were evaluated for both regular and controlled atmosphere (CA) operations for each size.

In the following section, requirements and costs of buildings and equipment excluding management are presented. Requirements and costs for variable cost items for the several situations follow the presentation of building and equipment costs. Total costs for all sizes and situations are compared at capacity and less than capacity operations.

Data for evaluating storing costs were obtained from several sources, but little information could be obtained from existing storage operations in North Carolina since only a few of these operations could be classified as anything other than temporary holding rooms. Engineers and equipment company representatives assisted in developing building and equipment specifications and costs. Storage studies in Washington, Virginia and New York provided supplementary data used to estimate operating requirements and costs.

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[7] This method has been used in many studies, e.g., Gene A. Mathia and Richard A. King, Planning Data for the Sweet Potato Industry 4, Costs and Returns from Curing, Storing, Grading and Packing Sweet Potatoes, A. E. Information Series 108, N. C. State University, 1963, and R. J. Peeler, Jr. and Richard A. King, In-Plant Costs of Grading and Packing Eggs, A. E. Information Series 106, Department of Economics, N. C. State University, Raleigh, 1963.

Results

Investment Costs

Building. Building costs comprise a large part of the total investment costs for storing apples. Storing apples is a relatively simple process and for regular storage, buildings and refrigeration equipment are the only large investment items. An additional item for CA operations is the investment in a mechanism for generating the desired atmosphere.

Buildings were designed for operating with and without pallets.[8] The only effect of pallet operations was that the building must be enlarged by one-half cubic foot per carton to allow for storage of the pallet. In Table 1, sizes of structures are given for both non-pallet and pallet operations. The type of storage (regular or controlled atmosphere) would not be expected to affect the size of the building but would affect the costs of the structure since CA operations require an air tight building.

Building costs for the 10,000 carton house ranged from $9,000 for regular non-palletized operations to $11,700 for CA palletized operations. The difference between palletized and non-palletized operations for any given capacity and for either regular or CA operations provide an indication of the additional costs of buildings to utilize pallets and a fork-lift. For example, adding space for pallet operations to an 80,000 carton regular storage facility would cost an additional $4,400.

Equipment. The major items of equipment include the costs of refrigeration in a regular storage house and refrigeration and CA equipment in a CA house. Other minor items of equipment were necessary for both packing and storing operations. It was assumed that additional investment in these items would not be necessary for the storage operation since the investment has already been made for the packing operation. In this case, these items would not represent an overhead cost for storage but were charged off as variable operating costs.[9]

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[8] Requirements and costs of pallet operations were calculated on the basis of a 48-box pallet measuring 40 inches by 48 inches.

[9] Overhead costs would need to be determined and allocated to the storage activity for any commercial storage operations in which leasing arrangements were being considered.

Table 1. Building requirements and costs of construction of varying capacities of operations[a]

Capacity	Size of building[b]		Construction costs[c]			
			Regular storage		Controlled atmosphere	
	Non-palletized	Palletized	Non-palletized	Palletized	Non-palletized	Palletized
(1,000 cartons)	(1,000 cubic feet)		(1,000 dollars)			
10	25	30	9.0	10.8	9.8	11.7
20	50	60	18.0	21.6	19.5	23.4
40	100	120	36.0	43.2	39.0	46.8
80	200	240	72.0	86.4	78.0	92.0

[a]Building requirements and cost estimates were derived from J. C. Thompson, Jr., Apple Storage Costs in New York State, A. E. Res. Report 87, Department of Agricultural Economics, Cornell University, Ithaca, New York, 1962.

[b]An apple carton requires about 1.4 cubic feet of space but allowances have to be made for aisles, pallets and other lost air space. Thus, space allocations were 2.5 cubic feet per box for non-palletized storage and 3.0 cubic feet per box for palletized storage. Building dimensions are available for each unit and can be obtained by writing to the Department of Economics, N. C. State University, Raleigh.

[c]Building costs for concrete block construction were estimated at $.36 per cubic foot for regular storage units and $.39 per cubic foot for controlled atmosphere units.

Requirements and costs of refrigeration for both regular and CA operations are presented in Table 2. These data were obtained from an engineer of a business firm selling refrigeration equipment. The basic problem in determining requirements involved specifying the work load, i.e., length of operating time and intensity of use of refrigeration unit. Work load was calculated on the basis of a 72 hour temperature pull-down period and a holding period with temperature of 32 degrees.[10]

[10]Larger capacity refrigeration units would be required if a more rapid rate of temperature pull-down is desired. Variations in refrigeration units can be built into particular size storage units without greatly affecting the level of costs.

Table 2. Refrigeration requirements and costs for regular and controlled atmosphere storage houses using non-pallet and pallet procedures[a]

Capacity, load rate and costs	Description	Procedure	
		Non-palletized	Palletized
10,000 cartons			
Load rate	tons/hr.	3.42	3.70
Costs	dollars	1270	1549
20,000 cartons			
Load rate	tons/hr.	7.34	7.72
Costs	dollars	2912	3971
40,000 cartons			
Load rate	tons/hr.	13.00	13.90
Costs	dollars	4579	5076
80,000 cartons			
Load rate	tons/hr.	25.00	25.77
Costs	dollars	7929	8406

[a]These costs do not include the air ducts or motorized louvers and values for controlling the air flow for each room separately. Cost for each room for motorized louvers and values was estimated at $200 and a by-pass valve was estimated at $200. The degree of temperature control desired would determine the need for these items.

The size of refrigeration units varied by type of storage and capacity of operation. Load rate and refrigeration costs do not differ between CA and regular storages. The small capacity house required 3.42 tons of refrigeration per hour for non-palletized operations and 3.70 tons for palletized operations. The costs of units ranged from a low of $1,270 per house with 10,000 bushels to $8,406 per house with 80,000 bushels.

The requirements and costs of an atmosphere controlled system are presented in Table 3. The type of operation had no effect on equipment requirements and costs since the equipment has excess capacity in each case.[11] It is possible to utilize either the carbon dioxide scrubber or oxygen converter or both jointly to provide controlled conditions.

[11]A very limited selection of sizes of equipment is currently available for commercial sale. Consequently, purchases of equipment with excess capacity would be necessary at this time. This problem will be solved as different sizes of units are constructed and placed on the market.

Table 3. Equipment requirements and costs of atmosphere controlled systems[a]

Item of equipment[b]	Description	Capacity (1,000 bushels) 10	20	40	80
		(dollars)[e]			
Carbon dioxide scrubber[c]	Process and reactivation blowers saturator/cooler, and isolation valves	4,568	4,568	9,975	9,975
Oxygen converter[d]	Catalytic oxidizer	2,095	2,095	3,518	3,518
Combination CO_2 scrubber and O_2 converter	CO_2 removal and O_2 conversion series	6,295	6,295	12,495	12,495

[a]Data supplied by equipment manufacturer.

[b]Life expectancy of absorbent and catalyst is in excess of five years. All units are warranted for a period of one year in accordance with mechanical Products Division warranty.

[c]The scrubber for the 10 thousand and 20 thousand bushel operations is rated at 30,000 bushel maximum capacity. It is designed to remove 3 pound CO_2 per hour. Air flow is rated at 50 CFM process and 40 CFM reactivation. The scrubber for the 40 thousand and 80 thousand bushel operations is rated at an 80,000 bushel maximum capacity. It removes 8 pounds of CO_2 per hour. Air flow is rated at 150 CFM process and 90 CFM reactivation.

[d]The O_2 converter for 10 thousand and 20 thousand bushel operations is rated at 10 thousand to 100 thousand bushels capacity. Air flow is rated at 20 CFM. The recommended O_2 converter per 40 thousand and 80 thousand bushel operation is rated at 40 thousand to 200 thousand bushel capacity. Air flow is rated at 40 CFM.

[e]Costs include a 5 percent charge for delivery and installation. Cost of the air duct system is included in cost of structures.

The manufacturer recommended the use of a combination unit for best results. Thus, this analysis evaluates storage costs on the basis of a combination unit.[12]

The same unit was used for the 10 thousand and 20 thousand carton operations but a larger unit was required for the 40 thousand and 80 thousand carton operations. Thus, the equipment was greatly underutilized in the case of both the 10 thousand and 40 thousand carton operations. The costs were $6,295 for the small unit and $12,495 for the large unit. The carbon dioxide scrubbers were the more expensive item.

Operating Costs

The two major components associated with operating a storage house are labor and eletricity. Less important items are costs of operating equipment, refrigeration materials and repairs and maintenance. Only electricity and labor are discussed in detail.

Electricity. The most important use of electricity is for power to operate the refrigeration and CA units. Electrical requirements for lights and miscellaneous needs are minor and very difficult to measure accurately. Requirements were estimated for each size of house by type and method of operation. Table 4 presents these estimated electrical requirements for 10,000 carton houses by months for both palletized and non-palletized operations. Monthly costs are presented along with monthly accumulated totals for regular and CA operations. The first month during loading and rapid temperature pull-down is the period requiring large amounts of electricity. Electrical requirements and costs are about one-third greater for controlled atmosphere than for regular storage. Additional power is required for operating the carbon dioxide scrubber and oxygen converter.

Monthly and accumulated costs of operating 20 thousand, 40 thousand and 80 thousand carton capacity facilities are presented in Tables 5, 6 and 7, respectively. Electrical costs are a relatively important item in all situations equalling almost $5,000 for a 210 day season when 80,000 cartons are stored under controlled atmosphere using the palletized method.

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[12] Adjustments in costs can be made easily if an individual wants to use only one type of unit.

Table 4. Monthly requirements and costs of electricity for a 10,000 carton capacity unit for non-palletized and palletized operations and for regular and controlled atmosphere storage

Type of operation and storage time	Requirements[a]		Costs		Accumulated costs	
	Regular	Controlled atmosphere	Regular	Controlled atmosphere	Regular	Controlled Atmosphere
	(KWH/mo.)		(dols./mo.)		(dols./season)	
Non-palletized						
Month						
1	9,900	14,280	149	214	149	214
2	4,500	6,690	68	100	217	314
3	4,500	6,690	68	100	285	414
4	4,500	6,690	68	100	353	514
5	4,500	6,690	68	100	421	614
6	4,500	6,690	68	100	489	714
7	4,500	6,690	68	100	557	814
Palletized						
Month						
1	10,890	15,720	163	236	163	235
2	6,534	9,432	98	141	261	377
3	6,534	9,432	98	141	359	518
4	6,534	9,432	98	141	457	659
5	6,534	9,432	98	141	555	800
6	6,534	9,432	98	141	653	941
7	6,534	9,432	98	141	751	1,082

[a]Electrical requirements for the non-palletized operation were calculated on the basis of a refrigeration unit operating for 20 hours per day during peak load with a rating of 40 amps. The peak load period was assumed to be 30 days after the fruit is placed in storage. After the peak load period, the unit was assumed to operate at 50 percent of its rated capacity. The same size refrigeration unit was required for the palletized operation but, because of additional space involved, 22 hours of operation per day during the peak load period was assumed. After the peak load period, the refrigeration unit was assumed to operate at 60 percent of its rated capacity. A 10 percent allowance was made for miscellaneous electrical needs for both types of operations. The price for electricity was quoted at 1.5 cents per KWH.

Table 5. Monthly requirements and costs of electricity for a 20,000 carton capacity unit for non-palletized and palletized operations and for regular and controlled atmosphere storage

Type of operation and storage time	Requirements[a]		Costs		Accumulated costs	
	Regular	Controlled atmosphere	Regular	Controlled atmosphere	Regular	Controlled atmosphere
	(KWH/mo.)		(dols./mo.)		(dols./season)	
Non-palletized						
Month						
1	10,890	15,730	163	236	163	236
2	6,534	9,438	98	142	261	378
3	6,534	9,438	98	142	359	520
4	6,534	9,438	98	142	457	662
5	6,534	9,438	98	142	555	804
6	6,534	9,438	98	142	653	946
7	6,534	9,438	98	142	751	1,088
Palletized						
Month						
1	13,200	16,420	198	246	198	246
2	7,920	9,852	119	148	317	394
3	7,920	9,852	119	148	436	542
4	7,920	9,852	119	148	555	690
5	7,920	9,852	119	148	674	830
6	7,920	9,852	119	148	792	986
7	7,920	9,852	119	148	912	1,134

[a]Electrical requirements were calculated for the non-palletized operation on the basis of a refrigeration unit operating 22 hours per day during the 30 day peak load period with a rating of 40 amps. After the peak load period, the unit was assumed to operate at 60 percent of its rated capacity. For the palletized operation, a refrigeration unit rated at 50 amps was required. During the 30 day peak load period, the unit was assumed to operate for 20 hours per day. The remaining period required 60 percent capacity use. A 10 percent allowance was made for miscellaneous electrical needs. A price of 1.5 cents per KWH was quoted by the electrical company.

Table 6. Monthly requirements and costs of electricity for a 40,000 carton capacity unit for non-palletized and palletized operations and for regular and controlled atmosphere storage

Type of operation and storage time	Requirements[a]		Costs		Accumulated costs	
	Regular	Controlled atmosphere	Regular	Controlled atmosphere	Regular	Controlled atmosphere
	(KWH/mo.)		(dols./mo.)		(dols./season)	
Non-palletized						
Month						
1	21,129	34,929	316	524	316	524
2	12,672	20,952	190	314	506	838
3	12,672	20,952	190	314	696	1,152
4	12,672	20,952	190	314	887	1,466
5	12,672	20,952	190	314	1,077	1,780
6	12,672	20,952	190	314	1,267	2,094
7	12,672	20,952	190	314	1,457	2,408
Palletized						
Month						
1	30,300	44,100	454	662	454	662
2	18,180	26,460	272	397	727	1,059
3	18,180	26,460	272	397	999	1,456
4	18,180	26,460	272	397	1,272	1,853
5	18,180	26,460	272	397	1,545	2,250
6	18,180	26,460	272	397	1,818	2,647
7	18,180	26,460	272	397	2,090	3,044

[a]Electrical requirements were calculated on the basis of a 30 day peak load period in which the refrigeration units operate for 20 hours per day. The rated capacity for non-palletized operation was 85 amps and at 120 amps for the palletized operation. After the peak load period, the units were assumed to operate at 60 percent of rated capacity. A 10 percent allowance was made for miscellaneous electrical needs. The price for electricity was quoted at 1.5 cents per KWH.

Table 7. Monthly requirements and costs of electricity for an 80,000 carton capacity unit for non-palletized and palletized operations and for regular and controlled atmosphere storage

Type of operation and storage time	Requirements[a]		Costs		Accumulated costs	
	Regular	Controlled atmosphere	Regular	Controlled atmosphere	Regular	Controlled atmosphere
	(KWH/mo.)		(dols./mo.)		(dols./season)	
Non-palletized						
Month						
1	44,220	58,020	663	870	663	870
2	26,532	34,812	398	522	1,061	1,392
3	26,532	34,812	398	522	1,459	1,914
4	26,532	34,812	398	522	1,857	2,436
5	26,532	34,812	398	522	2,255	2,958
6	26,532	34,812	398	522	2,653	3,480
7	26,532	34,812	398	522	3,051	4,002
Palletized						
Month						
1	56,760	70,560	851	1,058	851	1,058
2	34,056	42,336	511	635	1,362	1,693
3	34,056	42,336	511	635	1,873	2,328
4	34,056	42,336	511	635	2,384	2,963
5	34,056	42,336	511	635	2,895	3,598
6	34,056	42,336	511	635	3,406	4,233
7	34,056	42,336	511	635	3,917	4,868

[a]Electrical requirements were calculated on the basis of a 30 day peak load period in which the refrigeration units operate for 20 hours per day. The rated capacity for the non-palletized operation was 174 amps and at 225 amps for the palletized operation. After the peak load period, the units were assumed to operate at 60 percent of rated capacity. A 10 percent allowance was made for miscellaneous needs. The price of electricity was quoted at 1.5 cents per KWH.

Labor. Labor is required to place fruit in storage, for daily checks for diseases and operation of refrigerating units, and to load out of storage. Labor requirements depend on several factors but the technique used to handle the fruit is one of the more important considerations. A study by the U. S. Department of Agriculture evaluated the economic feasibility of several alternative techniques for handling apples in Washington state. The most economical method as determined by the USDA study was used in this study for both palletized and non-palletized methods. The equipment associated with the two methods would be utilized in the packing operations and would not entail additional investment for storage operations.[13] Total costs of operating this equipment were charged against the storage operations on an hourly basis, i.e., the investment costs in equipment were depreciated over time for output associated with both packing and storing operations.

Labor and equipment requirements and costs per 1,000 cartons using the non-palletized procedure are presented in Table 8. Data were not available to permit an evaluation of the effects of size of operation on labor requirements. Gravity roller conveyor, clamp-type, two-wheel hand truck and mechanical high-piler were utilized in the non-palletized operation. Placing in storage and the daily check operation required large quantities of labor. Placing in storage required 19 man-hours of labor per thousand cartons stored. Checking time for CA operations was a little less than for regular storage operations.

Hours of equipment use for placing in storage also totaled 19 man-hours but per hour costs were much lower than the costs of manual labor. The loading out operation also required the use of equipment but not at the same level as did the placing in operation.

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[13]The storage activity was considered as a separate yet integral part of the packing operation. Thus, requirements and costs of all factors of production have to be adjusted if the storage activity is completely separate from the packing activity. Hourly requirements and costs of labor developed from USDA Report No. 49 compared very favorably with those presented in another study by Stanley W. Burt, Apple Handling and Packing in the Appalachian Area, Marketing Research Report No. 476, USDA, Washington, D. C. For comparisons, see Table 6 of Burt's study.

Table 8. Labor and equipment requirements and costs per 1,000 cartons to store apples using non-palletized procedures[a]

Item[b]	Labor		Equipment[c]		Total costs
	Hours	Dollars	Hours	Dollars	(dollars)
Place in storage	19.0	28.50	19.0	4.30	32.80
Check time[d]					
Regular	9.5	14.25	0	0	14.25
Controlled atmosphere	8.0	12.00	0	0	12.00
Preparation, handling and cleaning[d]	4.3	6.45	0	0	6.45
Load out of storage	5.5	8.25	5.0	1.89	10.14
Total					
Regular	38.3	57.45	24.0	6.19	63.64
Controlled atmosphere	36.8	55.20	24.0	6.19	61.39

[a]Data were not available to evaluate the effects of size of operation on labor requirements.

[b]Requirements were estimated on the basis of a three-man crew moving 1,000 packed cartons of apples from the packing line to storage and piled 10 cartons high by use of gravity roller conveyor, clamp-type, two-wheel hand truck and mechanical high-piler. Transportation distances were standardized at 175 feet for moving packed cartons to storage and 160 feet for moving cartons from storage to load trucks. A wage rate of $1.50 per hour was used.

[c]The coefficients for the functions of placing in storage and loading out of storage were obtained from Earl W. Carlsen and Joseph F. Herrick, Jr., Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses, Marketing Research Report No. 49, U. S. Department of Agriculture, June 1953, Washington, D. C. Data were obtained from Tables 113 and 114 and Report No. 49, but adjusted by the cost index of new plant and equipment published in various issues of the Marketing and Transportation Situation, MTS Reports. The cost index of new plant and equipment increased by 33 percent from 1952 to 1966.

[d]Time involved in the checking and preparation, handling and cleaning operation for regular storage and controlled atmosphere was based on a maximum of 150 and 210 days in storage, respectively. The coefficients were obtained from Cornell A. E. Research Report 87, Apple Storage Costs in New York State.

For palletized operation, total labor and equipment costs did not differ greatly between regular and CA operations. Costs for regular storage totaled $63.64 per 1,000 cartons compared to $61.39 per 1,000 cartons for CA operations.

Labor and equipment requirements and costs for palletized operations are presented in Table 9. Fork-lift truck and pallets were used in palletized operations. Checking time required more man-hours than for the non-pallet methods but placing in and loading out of storage were reduced by adopting the palletized procedure. In fact, total costs of labor and equipment per 1,000 cartons handled were about $6.50 per thousand cartons less with pallet operations as can be observed by comparing Tables 8 and 9.

Miscellaneous. Two minor cost items are repairs and maintenance of building and equipment and refrigeration materials. For the latter, the operator has the alternative of using either freon or the ammonia system. Costs associated with both methods are presented in Table 10 but only the costs of freon are utilized in the discussion of combined costs which follows.[14] These costs are relatively minor and thus affect per unit costs very little.

Combined Costs

10,000 Carton Operation. A summary of the costs for a 10,000 carton house is presented in Table 11. The costs of management are excluded in all situations. The investment costs are first given in dollars but later depreciated out over the expected life of each item. Costs in dollars per 1,000 cartons per season are totaled for both regular and CA operations and for non-pallet and pallet methods. Costs per 1,000 cartons per season totaled $221 per 1,000 cartons for regular storage and non-palletized operations and $247 per 1,000 cartons for palletized operations. The added cost of changing from non-palletized to palletized operations was $26 per 1,000 cartons. This represents a 3-cent per carton differential between non-palletized and palletized operations at full capacity. Costs were 22 cents per carton for the non-palletized method and 25 cents per carton for pallet operations.

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[14] Freon, although somewhat higher in cost, is highly desirable as a refrigerant since it is noncombustible, nonflammable and noncorrosive. It is odorless and harmless to humans and apples and cannot cause off-flavor problems in apples.

Table 9. Labor and equipment requirements and costs per 1,000 cartons to store apples using palletized procedures[a]

Item[b]	Labor		Equipment[c]		Total costs
	Hours	Dollars	Hours	Dollars	(dollars)
Place in storage	7.5	11.25	7.5	7.25	18.50
Check time[d]					
Regular	12.9	19.35	0	0	19.35
Controlled atmosphere	11.4	17.10	0	0	17.10
Preparation, handling and cleaning[d]	4.3	6.45	0	0	6.45
Load out of storage	6.0	9.0	3.8	3.76	12.76
Total					
Regular	30.7	46.05	11.3	11.01	57.06
Controlled atmosphere	29.2	43.80	11.3	11.01	54.81

[a]Data were not available to evaluate the effects of size of operation on labor requirements.

[b]Requirements were estimated on the basis of a three-man crew moving 1,000 packed cartons of apples from the packing houses to storage by use of fork-lift trucks and pallets. Transportation distances were standardized at 175 feet to move fruit from the packing line to storage and 210 feet for moving cartons from storage to trucks. A wage rate of $1.50 per hour was used.

[c]The coefficients for the functions of placing in storage and loading-out of storage were obtained from Earl W. Carlsen and Joseph F. Herrick, Jr., Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses, Marketing Research Report No. 49, U. S. Department of Agriculture, Washington, D. C., June 1953, Tables 122, 123 and 146. Equipment costs were obtained from Report No. 49 but adjusted by the index of new plant and equipment published in various issues of the Marketing and Transportation Situation, MTS Reports. Index of new plant and equipment increased by 33 percent from 1952 to 1966.

[d]Time involved in the checking and preparation, handling and cleaning operation for regular and controlled atmosphere storage was based on a maximum of 150 to 210 days in storage, respectively. The coefficients were obtained from Cornell A. E. Research Report 87, Apple Storage Costs in New York State.

Table 10. Miscellaneous costs associated with regular and controlled atmosphere storage operations[a]

Item of expense	Description	Capacity of operation (1,000 cartons)			
		10	20	40	80
		(dollars)			
Repairs and maintenance	($11/1,000 cartons)	110	220	440	880
Refrigeration materials					
Freon system	b	125	250	356	451
Ammonia system	b	85	170	278	446

[a]The basic source of data for repairs and maintenance and refrigeration materials was J. C. Thompson, Jr., Apple Storage Costs in New York State, A. E. Research Report 87, Ithaca, New York.

[b]Costs of refrigeration materials including salt listed by Thompson for freon and ammonia systems are:

Capacity (1,000 cartons)	System*	
	Freon	Ammonia
	(dols./1,000 cartons)	
0-24	9.65	5.65
25-49	6.06	4.09
50-74	3.62	2.20
75 and up	2.79	2.72

*Additional costs of $2.85/1,000 cartons for charcoal to filter out off-flavor and to prevent scald were included in the above estimate.

Table 11 Costs of storing apples in regular and controlled atmosphere storage houses using pallet and non-pallet methods for a 10,000 carton operation

Item	Regular storage		Controlled atmosphere	
	Non-palletized	Palletized	Non-palletized	Palletized
	(dollars)			
Investment costs				
Building costs	9,000	10,800	9,800	11,700
Refrigeration	1,270	1,549	1,270	1,549
Controlled atmosphere system	----	----	6,295	6,295
Total	10,270	12,349	17,365	19,544
	(dollars/1,000 cartons/season)			
Seasonal costs				
Overhead				
Depreciation[a]	57.70	69.49	124.65	136.94
Taxes and insurance[b]	3.74	4.09	5.41	6.45
Interest[c]	30.81	37.05	52.10	58.63
Operating				
Labor	57.45	46.05	55.20	43.80
Electricity[d]	42.10	55.50	81.40	108.20
Equipment	6.19	11.01	6.19	11.01
Repairs and maintenance[e]	11.00	11.00	11.00	11.00
Refrigeration materials[f]	12.50	12.50	12.50	12.50
Total	221.49	246.69	348.45	388.53
	(dollars/carton/season)			
Total	.22	.25	.35	.39

Table 11 (continued)

[a]Depreciation was calculated using the straight line method assuming a zero salvage value on the basis of 20, 10, and 10 years, for building, refrigeration equipment and the controlled atmosphere equipment, respectively.

[b]Calculated at 2 percent of the overhead and operating costs except interest assuming capacity operations.

[c]Interest at 6 percent was calculated on one-half the total investment in buildings and equipment.

[d]Electricity was calculated on the basis of 150 days for regular and 210 days for controlled atmosphere operations.

[e]Estimates obtained from Cornell Research Report No. 87.

[f]Based on a freon system.

Costs for controlled atmosphere were $348 per 1,000 cartons for non-palletized and $389 per 1,000 cartons for palletized operations. The costs of palletized operations are $41 per 1,000 cartons greater than for non-palletized operations. At capacity operations, this difference is 4 cents per carton or represents a change from 35 cents per carton with non-palletized to 39 cents with palletized operations. Wage rates higher than the $1.25 per hour would tend to offset the cost advantage of the non-pallet method. No attempt was made to determine the wage rate in which pallets would become the less expensive method.

Costs for regular storage are 13 cents per carton less than for controlled atmosphere under non-palletized methods and 14 cents per carton less for palletized operations. These differences are meaningful only if it is recognized that the storage season for regular storage is considered to be 150 days but 210 days for controlled atmosphere. Additional costs of labor for daily checking the operations and electricity are incurred beyond 150 days for the CA operations. With this adjustment, however, costs for regular storage are considerably less than controlled atmosphere for a 150 day season. The price premium for apples stored for 150 days in controlled atmosphere relative to apples stored the same length of time in regular storage is not well known but would have to be estimated in order to make a choice between the two alternative methods of storage.

20,000 Carton Operation. A summary of costs for storing 20,000 cartons per season is presented in Table 12. Costs for regular storage of 21 cents per carton for non-palletized operations and 23 cents per carton for palletized operations indicate only 1- and 3-cent cost reductions from comparable unit costs for the 10,000 carton operations (compare Tables 11 and 12). The 2-cent cost differential between non-palletized and pallet operations is offset by the greater flexibility and speed involved in moving fruit by the more mechanized procedure involving the use of pallets and a fork-lift truck. Higher labor rates would also favor the pallet operations.

Costs for controlled atmosphere operations are considerably lower for the 20,000 carton operation than for the 10,000 carton operation. For example, for the non-palletized procedure, costs were 35 cents per carton for the 10,000 carton operation but decline to 28 cents per carton for the 20,000 carton unit (compare Tables 11 and 12). A 9-cent per carton differential existed between the two sizes for the palletized methods.

40,000 Carton Operation. Costs associated with the 40,000 carton operation are summarized in Table 13. Unit costs are lower for regular storage under both palletized and non-palletized operations, but 1 cent per carton higher for controlled atmosphere palletized operations than comparable situations for the 20,000 carton operation. The additional costs resulted from an investment in a larger controlled atmosphere unit which was required for the 40,000 carton operation but operated with unused capacity.

Large cost differences between regular and CA units resulted for the larger size units. The choice between regular or CA operations depends on the price received for apples after 150 days of storage in regular storage compared with the price of apples after 210 days of storage in CA units. It should be noted that a favorable price differential would have to prevail for several seasons before a decision is made to invest in controlled atmosphere rather than regular storage. Furthermore, a differential between the price at harvest and when apples are removed from storage would have to be expected to prevail for several seasons before an investment in either type of storage is economically feasible. The number of seasons in which a favorable price differential would have to exist depends on the opportunity costs of capital and sizes of the

Table 12. Costs of storing apples in regular and controlled atmosphere storage houses using pallet and non-pallet methods for a 20,000 carton operation

Item	Regular storage		Controlled atmosphere	
	Non-palletized	Palletized	Non-palletized	Palletized
	(dollars)			
Investment costs				
Building costs	18,000	21,600	19,500	23,400
Refrigeration	2,912	3,971	2,912	3,971
Controlled atmosphere system	----	----	6,295	6,295
Total	20,912	25,571	28,707	33,666
	(dollars/1,000 cartons/season)			
Seasonal costs				
Overhead				
Depreciation[a]	59.56	73.86	93.78	109.80
Taxes and insurance[b]	3.49	3.76	4.58	4.90
Interest[c]	31.37	38.36	43.21	50.50
Operating				
Labor	57.45	46.05	55.20	43.80
Electricity[d]	27.75	33.70	50.44	56.70
Equipment	6.19	11.01	6.19	11.01
Repairs and maintenance[e]	11.00	11.00	11.00	11.00
Refrigeration materials[f]	12.50	12.50	12.50	12.50
Total	209.31	230.24	276.90	300.21
	(dollars/carton/season)			
Total	.21	.23	.28	.30

Table 12 (continued)

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[a]Depreciation was calculated using the straight line method assuming a zero salvage value on the basis of 20, 10, and 10 years, for building, refrigeration equipment and the controlled atmosphere equipment, respectively.

[b]Calculated at 2 percent of the overhead and operating costs except interest assuming capacity operations.

[c]Interest at 6 percent was calculated on one-half the total investment in buildings and equipment.

[d]Electricity was calculated on the basis of 150 days for regular and 210 days for controlled atmosphere operations.

[e]Estimates obtained from Cornell Research Report No. 87.

[f]Based on a freon system.

Table 13. Costs of storing apples in regular and controlled atmosphere storage houses using pallet and non-pallet methods for a 40,000 carton operation

Item	Regular storage		Controlled atmosphere	
	Non-palletized	Palletized	Non-palletized	Palletized
	(dollars)			
Investment costs				
Building costs	36,000	43,200	39,000	46,800
Refrigeration	4,579	5,076	4,579	5,076
Controlled atmosphere system	----	----	12,495	12,495
Total	40,579	48,276	56,074	64,371
	(dollars/1,000 cartons/season)			
Seasonal costs				
Overhead				
Depreciation[a]	56.45	66.69	91.44	102.43
Taxes and insurance[b]	3.34	3.62	4.66	5.06
Interest[c]	30.42	36.20	42.05	48.28
Operating				
Labor	57.45	46.05	55.20	43.80
Electricity[d]	26.93	38.62	60.20	76.10
Equipment	6.19	11.01	6.19	11.01
Repairs and maintenance[e]	11.00	11.00	11.00	11.00
Refrigeration materials[f]	8.90	8.90	8.90	8.90
Total	200.68	222.09	279.64	306.58
	(dollars/carton/season)			
Total	.20	.22	.28	.31

Table 13 (continued)

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[a]Depreciation was calculated using the straight line method assuming a zero salvage value on the basis of 20, 10, and 10 years, for building, refrigeration equipment and the controlled atmosphere equipment, respectively.

[b]Calculated at 2 percent of the overhead and operating costs except interest assuming capacity operations.

[c]Interest at 6 percent was calculated on one-half the total investment in buildings and equipment.

[d]Electricity was calculated on the basis of 150 days for regular and 210 days for controlled atmosphere operations.

[e]Estimates obtained from Cornell Research Report No. 87.

[f]Based on a freon system.

favorable price differentials. In any case, the investment would have to be recouped over a period not greater than the useful life of the building and equipment. In this case, initial equipment costs would have to be recovered within a 10 year period.

80,000 Carton Operation. A summary of costs for the largest unit is presented in Table 14. Costs for regular storage operations changed very little from the 40,000 carton operation (compare Tables 13 and 14). Per unit costs for CA operations were reduced considerably for this size operation as compared with either of the three smaller units. The CA equipment was utilized more efficiently for the 80,000 carton unit since investment costs were spread over a larger volume.

The cost differentials between regular and CA operations were also reduced considerably. For example, cost differentials of 4 and 5 cents per carton were observed between regular storage and CA operations for both palletized and non-palletized operations.

The costs for all sizes of operations compare very favorably with costs presented in the New York study. Costs for controlled atmosphere were somewhat lower than those presented in New York, but recent technological developments in CA equipment could account for this reduction.

Economies of Size. The previous sections described the costs associated with each size of storage unit. This information is useful to an investor if the decision regarding size of unit has already been made. A comparison of how costs vary as size of operation varies provides additional information useful to those investors who are interested not only in the question of whether to invest in storage but also in the question of how large a storage unit to construct. This question cannot be answered with only cost information. The price of the product is needed so that net returns to management and investment can be estimated. Since the price of the product for an individual firm would not be expected to vary by size of operation, costs of storing apples provide an indication of the most desirable size of unit.

Per unit costs of storage are expected to decline as the size of the operation increases at any given capacity. In Figure 2, costs of storing apples in regular and CA storage using pallet and non-pallet methods can be compared. Costs per carton using the CA method decrease sharply from 35 cents using non-pallets and 39 cents using pallets for

Table 14. Costs of storing apples in regular and controlled atmosphere storage houses using pallet and non-pallet methods for an 80,000 carton operation

Item	Regular storage		Controlled atmosphere	
	Non-palletized	Palletized	Non-palletized	Palletized
	(dollars)			
Investment costs				
Building costs	72,000	86,400	78,000	92,000
Refrigeration	7,929	8,406	7,929	8,406
Controlled atmosphere system	----	----	12,495	12,495
Total	79,929	94,806	98,424	112,901
	(dollars/1,000 cartons/season)			
Seasonal costs				
Overhead				
Depreciation[a]	54.91	64.50	74.28	83.63
Taxes and insurance[b]	3.27	3.49	4.05	4.32
Interest[c]	29.98	35.55	36.91	42.34
Operating				
Labor	57.45	46.05	55.20	43.80
Electricity[d]	28.19	36.19	50.03	60.85
Equipment	6.19	11.01	6.19	11.01
Repairs and maintenance[e]	11.00	11.00	11.00	11.00
Refrigeration materials[f]	5.64	5.64	5.64	5.64
Total	196.63	213.43	243.30	262.59
	(dollars/carton/season)			
Total	.20	.21	.24	.26

Table 14 (continued)

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[a]Depreciation was calculated using the straight line method assuming a zero salvage value on the basis of 20, 10, and 10 years, for building, refrigeration equipment and the controlled atmosphere equipment, respectively.

[b]Calculated at 2 percent of the overhead and operating costs except interest assuming capacity operations.

[c]Interest at 6 percent was calculated on one-half the total investment in buildings and equipment.

[d]Electricity was calculated on the basis of 150 days for regular and 210 days for controlled atmosphere operations.

[e]Estimates obtained from Cornell Research Report No. 87.

[f]Based on a freon system.

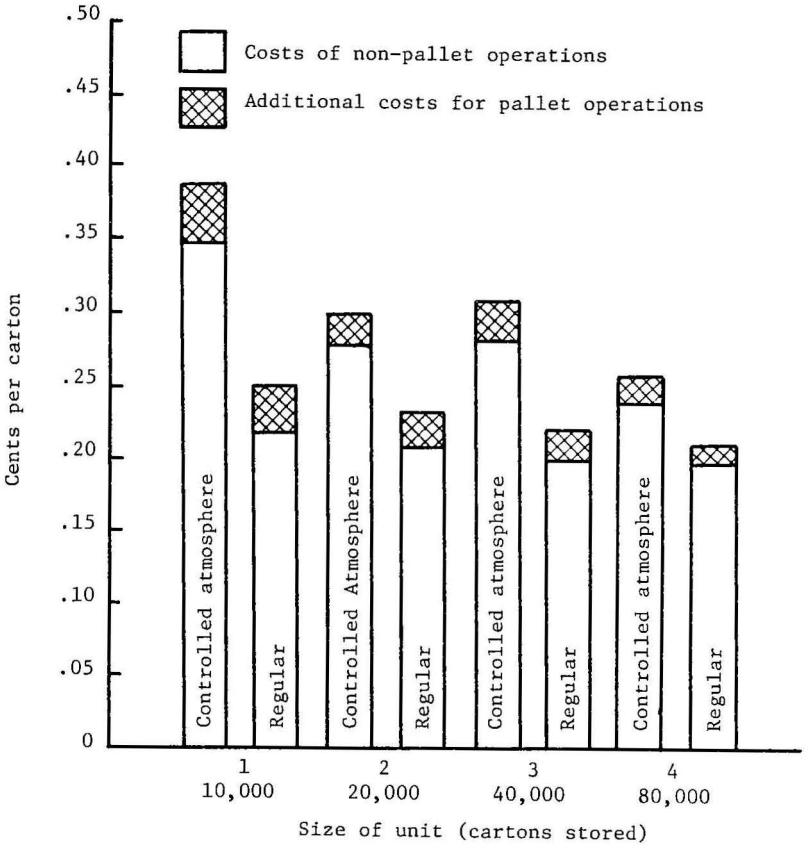

Figure 2. Costs associated with storing apples in regular and controlled atmosphere operations and non-palletized and palletized methods assuming capacity operations

the 10,000 carton unit to 28 cents using the non-pallet method and 30 cents using the pallet method for the 20,000 carton unit. Costs per carton gradually decline for both methods for the 40,000 and 80,000 carton units compared with the 20,000 carton unit.

Costs per carton decline gradually for both non-pallet and pallet methods under regular storage as the size of units increases from 10,000 to 80,000 cartons. For regular storage, little reduction in per unit costs with respect to size was observed. This small reduction could be offset by failure to operate the larger units at the given capacity. Less than capacity levels will be evaluated in the following section.

Effects of Less Than Capacity Operations

Storage operators may find it profitable many years not to utilize the storage house at capacity. The price at harvest may be relatively favorable when compared to the expected price at the end of the storage period. Also, the quality and quantity of apples during any particular season may not be satisfactory for storage. The question then facing the operator is how costs of storing are affected by less than capacity operation and how costs of storing apples at less than capacity compare with costs and returns from apple sales at harvest.

The effects of less than capacity operations can be evaluated by adjusting the costs which would be expected to change with changes in the volume stored. The costs per unit of several items would change with changes in volume stored. Per unit costs of variable operating items would not be expected to change greatly with the possible exception of electricity, and well designed buildings with adequate partitioning may allow changes in volume stored without greatly affecting this cost.

Unit costs of buildings and equipment, insurance, and taxes would be expected to increase since these costs are not directly related to the annual output level. The effects of less than capacity operations were evaluated by comparing costs at 50 and 75 percent of capacity for each situation. Costs at 50 and 75 percent capacity levels were estimated on the assumption that unit costs for variable operating items were not affected by volume changes.

A summary of unit costs at 100, 75 and 50 percent of capacity is presented in Table 15. For regular storage operations, costs for the

Table 15. Costs associated with operating four sizes of regular and controlled atmosphere storage facilities at three capacity levels

Size and method of operation	Type of storage					
	Regular			Controlled atmosphere		
	Level of operation (percent)					
	100	75	50	100	75	50
	(cents per carton)					
10,000 cartons						
Non-pallet	22	27	31	35	44	53
Pallet	25	30	36	39	49	59
20,000 cartons						
Non-pallet	21	26	31	27	35	42
Pallet	23	29	35	29	38	47
40,000 cartons						
Non-pallet	20	25	29	28	35	42
Pallet	22	28	33	31	38	46
80,000 cartons						
Non-pallet	20	24	28	24	30	36
Pallet	21	27	32	26	33	39

10,000 carton unit increased from 22 cents at 100 percent capacity to 31 cents per carton at 50 percent capacity for non-palletized operations. The increase was much greater for the same situation under CA conditions, i.e., costs were 35 cents per carton at 100 percent but increased to 53 cents per carton at 50 percent capacity. This is an indication that capacity operations are critical to the success of the storage activity at the 10,000 carton level.

The effects of capacity operations are less pronounced at the 80,000 carton level. Costs increase only 8 and 12 cents per carton for 50 percent compared with 100 percent for this size unit considering both regular and controlled atmosphere when utilizing the non-palletized method. Costs are 11 and 13 cents per carton greater for 50 percent compared with 100 percent for the pallet method and for both types of storage.

Summary

A study of storage costs for several sizes and types of operating situations was undertaken to provide planning data to existing packers who have expressed interest in considering alternatives for providing greater flexibility in their marketing program. Apple storage has not been commonly practiced in North Carolina but anticipated increases in production may necessitate other outlets in addition to increased fresh market sales.

There are two types of storage commonly used in major apple producing areas of the nation. Both regular and controlled atmosphere are used extensively in New York, Washington and Michigan with the volume placed under controlled atmosphere increasing relative to the volume placed in regular storage. Costs for four sizes were developed for both types of storage.

Packers in North Carolina also use various types of equipment in their packing operations. Since this equipment would likely be used in their storage operations, pallet and non-pallet operations were evaluated for both regular and CA operations.

The economic-engineering method was used to construct cost estimates by size, type and method of operations. Data were obtained from several studies conducted in Washington, Virginia and New York. Costs were first estimated and compared assuming capacity operations. The effects of 50 and 75 percent of capacity were later evaluated and compared with costs at capacity.

Building and equipment costs were very important cost items at all sizes of operation. Electrical cost was the most important item associated with operations and became more important for CA operations.

Costs for a 10,000 carton operation varied from a low of 22 cents per carton using regular non-palletized operations to 39 cents per carton for CA palletized operations. The different lengths of storage periods for the two methods account for a large share of these cost differences. The costs for pallet operations were 3 cents more for regular storage and 4 cents more for CA storage.

The effects of size of operation were important for the 10,000, 20,000 and 40,000 carton operations. However, costs for the 80,000 carton operation were only slightly lower than for the 40,000 carton operation. The

effects of size were more pronounced for controlled atmosphere than for regular storage.

The effects of less than capacity operations were important for the two smaller sized units and for controlled atmosphere at all sizes of operations. For regular storage, costs increased from 9 to 11 cents per carton at 50 percent capacity compared to 100 percent capacity under the various situations. Costs changed from 12 to 20 cents per carton for controlled atmosphere for the various sizes of operations. The differences in costs indicate the reduction in cost of utilizing the operations at near capacity.

An accompanying study is being conducted to evaluate the profitability of storing apples under prevailing prices for fresh and stored apples. The cost estimates derived here are utilized in the accompanying study. The profitability of storage is evaluated by comparing storage costs with price differentials between fresh market sales and the sale of apples throughout the storage period.

SELECTED BIBLIOGRAPHY

Burt, Stanley, W., *Apple Handling and Packing in the Appalachian Area,* Marketing Research Report No. 476, U. S. Department of Agriculture, Washington, D. C., June 1961.

Carlsen, E. W. and J. F. Herrick, Jr., *Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses,* Marketing Research Report No. 49, U. S. Department of Agriculture, Washington, D. C., June 1953.

Dalrymple, Dana G., *The Development of Controlled Atmosphere Storage of Fruits,* Division of Marketing and Utilization Sciences, Federal Extension Service, U. S. Department of Agriculture, Washington, D. C., 1967.

Mathia, G. A. and R. A. King, *Planning Data for the Sweet Potato Industry: (4) Costs and Returns for Curing, Storing, Grading and Packing Sweet Potatoes,* Department of Economics, N. C. State University, A. E. Information Series 108, December 1963.

Pasour, E. C., Jr., *Production, Marketing and Prices of North Carolina Apples, 1947-1963,* Department of Economics, N. C. State University, A. E. Information Series 117, March 1965.

Pasour, E. C., Jr. and G. A. Mathia, *Estimation of 1974 Apple Production In North Carolina--A Comparison of Three Predictive Procedures,* Department of Economics, N. C. State University, Economic Research Report 1, January 1967.

Peeler, R. J., Jr. and R. A. King, *In-Plant Costs of Grading and Packing Eggs,* Department of Economics, N. C. State University, A. E. Information Series 106, August 1963.

Thompson, J. C., Jr., *Apple Storage Costs in New York State,* Department of Agricultural Economics, Cornell University, A. E. Research Report 87, March 1962.

U. S. Department of Agriculture, *Crop Production,*1966 Annual Summary, CR-PR2-1(66), Washington, D. C., 1966.

U. S. Department of Agriculture, *Fruit Situation,* Economic Research Service, TFS-158, Washington, D. C., January 1966.

Appendix Table 1. North Carolina apple storage holdings, monthly, 1956-1966[a]

Crop year	Nov. 1	Dec. 1	Jan. 1	Feb. 1	Mar. 1	Apr. 1	May 1	June 1
	(thousand bushels)							
1956	303.2	195.4	99.2	75.0	34.1	14.0	4.1	4.2
1957	231.9	135.9	76.2	38.9	23.2	9.3	6.1	3.0
1958	483.5	265.0	140.3	92.3	56.2	25.3	9.5	7.0
1959	290.3	159.5	39.4	21.2	13.3	12.1	4.7	3.6
1960	318.3	227.5	146.0	73.9	32.0	8.8	6.1	2.6
1961	506.7	402.8	141.8	65.3	22.3	7.5	4.0	2.6
1962	313.2	182.6	86.1	36.3	11.7	8.6	5.0	3.6
1963	319.0	192.7	94.1	46.7	19.2	11.6	7.6	5.1
1964	598.2	260.3	160.9	98.2	31.3	21.1	7.8	5.7
1965	825.4	495.0	226.6	90.0	39.9	6.3	3.4	4.7
1966	492.8	171.3	55.6	14.2	9.9	7.7	4.9	5.8

[a]Source: International Apple Association, Monthly Storage Reports, as published in E. C. Pasour, Jr., Production, Marketing and Prices of North Carolina Apples, 1947-1963, A. E. Information Series No. 117, Department of Economics, N. C. State University, Raleigh, March 1965.

Appendix Table 2. Total apple storage holdings on the first of the month, United States, 1956-1966[a]

Month	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
	(million bushels)										
November	45.1	59.0	58.3	54.0	49.0	56.6	58.6	65.2	65.1	64.5	63.5
December	39.2	50.4	50.7	46.8	40.3	49.9	48.1	53.9	55.9	56.0	52.9
January	30.1	39.0	39.5	35.0	30.6	37.7	37.5	42.1	43.1	42.2	41.1
February	21.2	27.8	30.0	25.4	22.7	26.9	27.4	31.0	32.6	31.1	31.1
March	13.8	18.5	21.9	17.4	15.9	18.6	19.0	21.3	23.6	21.5	22.6
April	7.8	9.7	14.6	9.7	9.4	10.8	11.8	12.6	15.0	13.1	15.6
May	3.6	4.3	8.2	4.6	4.7	5.8	6.3	6.6	9.0	7.2	9.5
June	1.2	1.3	4.1	1.3	1.7	2.1	2.1	2.7	4.0	2.8	4.6

[a]Source: International Apple Association, Monthly Storage Reports, various issues.

Appendix Table 3. Controlled atmosphere apple storage holdings by month, United States marketing seasons, 1957-1966[a]

Month	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
					(thousand bushels)					
November	1,729	3,200	3,951	4,599	6,646	8,491	10,018	12,481	12,547	12,963
December	1,729	3,200	3,951	4,598	6,646	8,491	10,018	12,481	12,912	13,206
January	1,729	3,200	3,951	4,560	6,631	8,515	9,948	12,476	12,927	13,204
February	1,729	3,159	3,851	4,426	6,540	8,294	9,443	11,782	12,373	12,546
March	1,695	3,137	3,308	3,828	6,042	7,300	8,221	10,334	10,605	8,951
April	1,298	2,735	2,212	2,472	4,226	5,392	5,941	7,580	7,757	8,427
May	553	1,729	987	1,241	2,404	3,168	3,296	4,462	4,427	4,866
June	0[b]	695	262	325	778	1,009	1,018	1,623	1,591	2,060

[a]Source: International Apple Association, Monthly Storage Reports, various issues.

[b]All controlled atmosphere storage reported marketings complete as of June 1 in 1957 except for a few miscellaneous lots.

Agricultural Experiment Station

North Carolina State University
at Raleigh

R. L. Lowvorn, Director of Research

Bulletins of this station will be sent free to all citizens of the state who request them.