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Apples - Marketing

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**AN ANALYSIS OF
APPLE MARKETING AND STORAGE:
North Carolina Market Area**

**GENE A. MATHIA
AND
E. C. PASOUR, JR.**



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SUMMARY

At the present time, most of the North Carolina apple crop is marketed at harvest. An earlier maturity date for Red and Yellow Delicious varieties relative to other commercial apple production areas historically has given North Carolina producers a marketing advantage for early season sales. North Carolina apple production is now expanding at a rapid rate. In view of the projected levels of production, many people are concerned with the effect of increased sales on harvest price and on the most profitable marketing pattern.

Apple storage by North Carolina producers during the post World War II period has not generally been very profitable. In view of the rapidly increasing levels of production, however, many people are becoming interested in apple storage to extend the marketing period. Yet, other people feel that much larger quantities of apples could be sold on the fresh market at the time of harvest without having a large adverse effect on price.

This study was designed to provide information concerning both the profitability of apple storage and the responsiveness of apple prices to changes in sales. Specifically the objectives were to: (1) set forth an analytical procedure which may be useful in evaluating the profitability of storage, (2) estimate the price-quantity relationship for apple shipments to the North Carolina market area throughout the marketing season, and (3) use information on storage costs and seasonal price changes to assess the profitability of apple storage in the North Carolina market area.

The sensitivity of price to changes in sales during various periods of the marketing season was determined through use of a demand model constructed for the North Carolina apple marketing area. The North Carolina apple market area for the purposes of this study was taken to be the 29-city area which received USDA officially reported unloads from North Carolina during the 1956-1966 period.

Results of this model indicate that the demand for apples is very elastic early in the marketing season. This suggests that North Carolina apple prices are not likely to be very sensitive to changes in quantity of sales early in the marketing season. If demand elasticity is, in fact, greater in the early months, it also suggests that larger volumes could be moved into existing markets with less effect on price than in later months.

A storage model describing cost relationships was presented. The profitability of storing apples in regular and CA facilities was evaluated using storage cost estimates from a recent study and actual price differences by months from 1956 to 1966. On the basis of the cost data, regular storage for sales during December or January would not be a profitable investment unless the increase in price was greater than 20 cents per carton. During the 11 years studied, the price in December and January did not increase 20 cents and was often less than the August price.

Controlled atmosphere storage of apples appears to offer promise if North Carolina apple quality can be maintained at quality levels equal to apples stored in other areas until March. Storage beyond March is possible in northern areas, but a problem of maintaining acceptable quality arises if apples are stored in August and held in storage beyond March. In fact, the assumption of equal quality of apples from North Carolina compared with apples from other areas is questionable.

Operating costs of both CA and regular storage facilities for sizes larger than 10,000 cartons total about 2 and 3 cents per carton per month, respectively. Thus, total operating costs for storing apples from August to March are about 14 cents for CA facilities which is lower than actual seasonal price increases for most of the years studied. Regular storage was profitable in several years where facilities were assumed to be available but not as profitable as CA storage.

Storage of apples in producing areas with later harvesting dates (October) appeared very profitable when actual price differences between October and March for all years from 1958-1966 were compared with storage costs. If facilities were assumed available, storage activities during October were profitable every season during the

9-year period since operating costs total 10-12 cents per carton while the smallest seasonal price increase was 28 cents per carton in 1963. Available CA storage operations would yield a greater return per unit, since operating costs for CA are lower than for regular storage facilities and the price received for CA apples may be greater than the average price.

AN ANALYSIS OF APPLE MARKETING AND STORAGE: North Carolina Market Area

INTRODUCTION

Apple production in North Carolina has been gradually increasing since World War II. Recent plantings of trees and increases in yield indicate that North Carolina will experience further increases in apple production over the next few years. A study by Pasour and Mathia indicated that production could surpass 7 million bushels by 1974.¹ This volume would represent a 170 percent increase over the average level of production during the period 1960-1964. Yet, many people closely associated with the apple industry suspect that this estimate is somewhat low. In any event, increased production will likely intensify marketing problems.

For many years apple producers in North Carolina have been able to take advantage of favorable early season prices due to a slightly earlier harvesting season for North Carolina apples relative to apples produced in other areas. Currently a major part of the North Carolina apple crop of Red and Yellow Delicious varieties is marketed within a three-week period early in the season.

The projected increase in production, if realized, will likely lead to problems in harvesting and marketing in the early weeks of the marketing season. Quantities of labor needed to pick and pack the increased

¹E. C. Pasour, Jr. and Gene A. Mathia, Estimates of 1974 Apple Production in North Carolina--A Comparison of Three Predictive Procedures, Economics Research Report No. 1, Department of Economics, N. C. State University at Raleigh, January 1967.

volume will place additional pressure on an already tight labor supply at the prevailing custom rate for harvesting apples.

What would be the effect of selling increased quantities of apples on the fresh market? This is a very important question facing North Carolina producers. Specifically, the major concern involves the effect of selling larger volumes on early season prices. The effect may be quite different depending upon how and when the apples are marketed. The range of possibilities includes selling larger volumes in markets currently served as well as establishing new markets.

The potential of selling early fresh apples in new geographically separated markets is not known. It may be possible to expand the sales area considerably by extensive merchandising and sales efforts. The possibility of moving large volumes through export channels is also being proposed. If the demand for early season apples is very elastic, an increase in shipments to presently supplied markets in the three-week harvest period would not result in large price reductions. The costs of establishing market contacts and shipping apples to more distant locations may limit the profitable opportunities for this type of market expansion.

Processing and storage are two alternatives that are used extensively in other major apple producing states.² Storage has been suggested as a profitable alternative for North Carolina apple producers since apples currently produced hold up quite well under normal storage conditions. Storage facilities are inexpensive relative to the cost of processing facilities and can be constructed in a shorter period of time. Storage enables greater flexibility in selling apples over a longer period of time. Different storage methods are explained in a later section of this report.³

²A study is now in progress by the Economics Department of N. C. State University to evaluate the feasibility of expanding the apple processing industry in North Carolina.

³Costs of various kinds and sizes of storage facilities were presented in Gene A. Mathia's Costs of Storing North Carolina Apples, Econ. Info. Report 5, Department of Economics, N. C. State University at Raleigh, November 1967.

This study examined several questions. Is apple storage profitable in North Carolina? What is the optimum sales pattern for fresh and stored apples? How sensitive is the price of apples to changes in apple sales during various periods of the marketing season? What framework might a producer use in deciding on the optimum sales pattern, i.e., in determining the quantity to sell at harvest, the quantity to hold in regular storage for sale in a relatively short period of time, and the quantity to store for sale during a longer period of time?

Objectives

The specific objectives of the study were to (1) set forth an analytical procedure which may be useful in evaluating the profitability of storage, (2) estimate the price-quantity relationship for apple shipments to the North Carolina market area⁴ throughout the marketing season, and (3) use information on storage costs and seasonal price changes to assess the profitability of apple storage in the North Carolina market area.

Procedure

An analysis of the storage alternative provides information regarding conditions for profitable marketing choices. The conditions for profitable storage were set forth in a model developed for this purpose. This model requires information concerning demand conditions along with storage costs for various periods of the marketing season.

A framework for viewing the relationship between storage costs and the profitability of storing apples was developed. Appropriate costs in making storage decisions depend on the length of time the product is stored and on whether or not an investment in facilities has already been incurred. Results of an earlier study provided data on costs of storage as related to the length of storage period, type of storage, and size of storage unit.⁵

⁴For the purposes of this study, the North Carolina market area was taken to be the 29-city area to which apples are shipped from North Carolina and for which unload data are compiled by the U. S. Department of Agriculture.

⁵Mathia, op. cit.

A demand model was developed to estimate the relationship between price and quantity of apple shipments throughout the marketing season. The model assumed that the slope of the demand curve was the same throughout the marketing season and allowed only the level of demand to change. Results of the demand section were then combined with those of the storage model to draw implications for firms shipping apples to the North Carolina market area.

APPLE STORAGE

The most profitable quantity of apples to store depends both upon seasonal price variations and costs of storage. In this section a framework for viewing storage cost relationships is presented. Also, costs of storing apples are presented for a range of conditions for both regular and controlled atmosphere methods of storage.⁶ A brief discussion of the effect of storage on market quality follows.

Storage Methods and Market Quality Considerations

Both regular and controlled atmosphere storage extend the period of time in which apples are marketable. Of course, quality of fruit is not improved by storage, but the rate of deterioration is greatly reduced by favorable storage conditions.

A comparison of regular and CA facilities and consideration of how each extends the length of the marketing season provides a basis for comparing storage costs for both methods. Dewey set up a schedule of the relative lengths of time that apples retain acceptable market quality under various conditions of storage and handling.⁷ Losses in quality at each stage were rated in terms of units per day. Dewey's classification of quality loss beyond the optimum maturity date for some of the more important factors are:

⁶Controlled atmosphere storage (CA) refers to apple storage in special storage facilities where the level of carbon dioxide as well as the temperature is controlled.

⁷D. I. Dewey, "Is the 90-Day Requirement Realistic?--Michigan Results," pp. 65-67 in Controlled Atmosphere Storage Seminar Proceedings, 1966, Cornell University, Ithaca, New York.

<u>Operations</u>	<u>Loss in Quality</u> (units per day)
1. Harvest period, with apples still on the tree	5
2. Storage, during loading and cooling	3
3. Storage, at low temperature	1
4. Storage, under CA conditions with low CO ₂	1/2
5. Packing and marketing	10

A loss of 300 units according to the Dewey scale represents the limit of acceptable market quality. Therefore, a grower can determine the maximum time that can be allocated to each operation. The loss in quality is much slower for apples stored in CA than in regular storage facilities. For example, suppose that apples could be harvested within 10 days of the optimum maturity date, placed in storage within 5 days, and packed and marketed within an eight-day period after they were removed from storage. The length of time in which apples could be left in regular storage (under the above conditions) would be 155 days. Under CA conditions, apples could be stored for 310 days. The period for marketing apples of a satisfactory quality would vary according to the time required to harvest mature fruit, prepare for storage and pack for final sale. In any case, CA storage provides the individual with much more flexibility in marketing his fruit.

The following section illustrates how storage costs vary by type of storage, by length of storage season, and by quantity stored.

Storage Cost Relationships

The choice of alternative marketing outlets depends on the length of time under consideration. Each alternative is evaluated in terms of what it contributes in net returns to the firm's resources. The decision in the short run is relatively simple. Within a single marketing season, however, there is often a great deal of uncertainty at the time the allocation decision is made concerning the potential returns from alternative methods of marketing. The evaluation process becomes much more complicated when the alternatives involve long-run decisions.

The difficulty in the long run arises from the uncertainty involved in measuring or predicting economic conditions which affect the profitability of an investment. Storage, in general, is profitable only if

the seasonal price increase is greater than the cost of storage.⁸ An investment in storage facilities is not likely to be recouped in a single production period. Therefore, the decision to build storage facilities is a long-run investment decision requiring an evaluation of all resources. After the facility is constructed, operating costs of storage determine whether apples should be stored in any particular season, and if so, when they should be removed from storage and shipped to market.

The basic problem can be stated simply as: What allocation of a total apple crop between the fresh market at harvest and storage will maximize net returns over several years? This question can be answered only after costs and returns from apples sold at harvest and from storage are determined.

Total overhead costs of storing apples were estimated for regular and CA storage facilities by depreciating out the investment over time.⁹ The costs of all other resources utilized during the storage season were then added to these annual overhead costs to obtain the total storage costs. Cost relationships for both CA and regular storage units consist of a component not related to volume and a component related to both volume and length of the storage period. In Figure 1, 0a represents annual overhead costs for a 40,000-carton regular storage (RS) facility (non-palletized). In the same figure, 0b represents annual overhead costs for the same size CA storage facility. These costs are assumed to be the same regardless of volume stored.¹⁰ Costs associated with

⁸Seasonal price trends are influenced by the total quantity of apples stored. The seasonal increase in price is greater when relatively small quantities of the product are stored. In making storage decisions, the individual firm needs to consider both the total quantity of apples produced and the total quantity which will be stored.

⁹Storage costs for a range of conditions are presented in the following section.

¹⁰However, as shown in the costs of storage section, there are economies of size in constructing apple storage facilities. That is, the average storage cost per bushel is lower for larger storage facilities. This advantage is due primarily to lower annual overhead costs. However, the annual overhead cost would be constant (or nearly so) for any given size of storage facility.

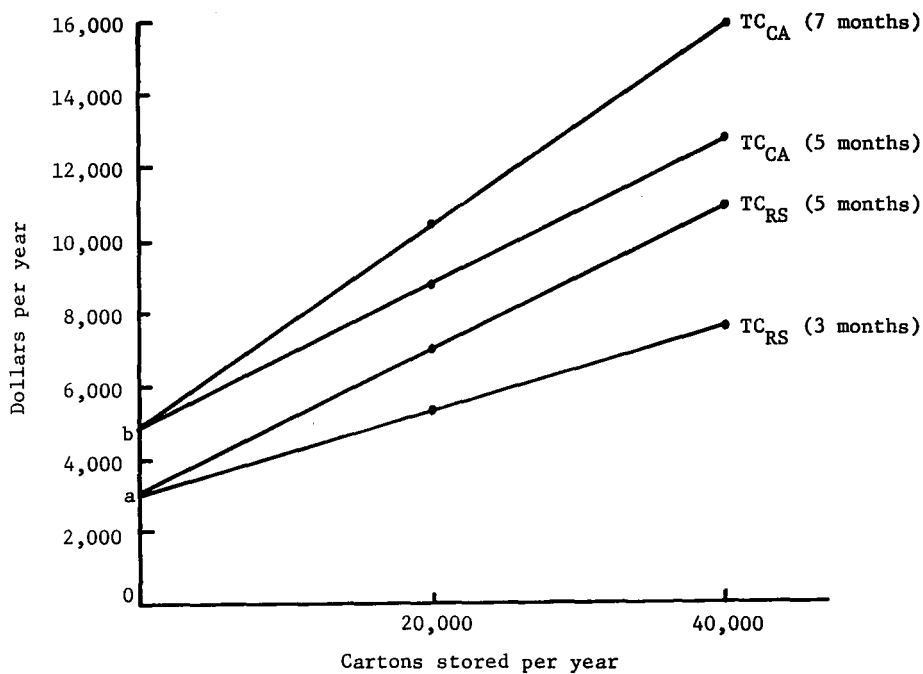


Figure 1. Apple storage cost relationships for a 40,000-carton storage facility equipped for regular or CA storage for selected time periods

Source: G. A. Mathia, Costs of Storing North Carolina Apples, Econ. Info. Report 5, Department of Economics, N. C. State University at Raleigh, November 1967.

volume are shown by the slope of each relationship. Cost variations associated with time in storage are represented by a change in slope of the relationships by type of storage as from TC_{RS} (3 months) to TC_{RS} (5 months). Differences in costs associated with type of storage are represented by a shift in the relationships as from TC_{RS} (5 months) to TC_{CA} (5 months).

For example, consider the 20,000- and 40,000-carton volumes (Figure 1). The increase in costs associated with storing the larger volume (40,000 instead of 20,000 cartons) in regular storage for three months is indicated by the slope of the curve TC_{RS} (3 months). If 20,000 cartons of apples are stored for five months instead of three, the vertical distance between TC_{RS} (3 months) and TC_{RS} (5 months) is the added storage cost. The distance between TC_{RS} (5 months) and TC_{CA} (5 months) at, say 20,000 cartons, shows the increase in cost for storing this volume of apples in CA instead of regular storage. Hence, Figure 1 depicts how storage costs for both CA and regular storage facilities having a capacity of 40,000 cartons are influenced both by changes in volume stored and by the length of storage period. More complete storage cost data for this and other sizes of facilities are presented in the following section.

Costs of Storage

Data on operating and overhead costs of storage were available for four sizes of houses (both CA and regular) and three capacity levels (Table 1).¹¹ Costs of storage were estimated on the basis of 150 days for regular and 210 days for CA storage although acceptable market quality could be maintained for longer periods. Sales of apples stored in August and September and sold after February would likely come from CA storage. Costs for longer periods could be estimated by calculating variable or operating costs.

Costs of controlled atmosphere storage ranged from a low of 24 cents per carton for the 80,000-carton facility operated at capacity to 53 cents per carton for the smallest (10,000-carton) house when operated

¹¹ Mathia, op. cit., for the conditions and assumptions under which storage costs were estimated.

Table 1. Operating and overhead costs associated with four sizes of regular and controlled atmosphere storage operations at three capacity levels using a non-pallet method

Size of operation (1,000 cartons)	Level of operation (percent of capacity)		
	50	75	100
(cents per carton per season)			
Regular storage ^a			
10	31	27	22
20	31	26	21
40	29	25	20
80	28	24	20
Controlled atmosphere storage ^b			
10	53	44	35
20	42	35	27
40 ^c	42	35	28
80	36	30	24

^a Assumes a storage period of five months.

^b Assumes a storage period of seven months.

^c One usually finds that average costs (costs per unit) decrease as volume increases. However, CA costs were higher for the 40,000-carton house at 100 percent of capacity (relative to the 20,000-carton house) since larger equipment was required but was not fully used.

Source: Gene A. Mathia, Costs of Storing North Carolina Apples, Department of Economics, Information Report 5, N. C. State University at Raleigh, 1967.

at 50 percent capacity.¹² The largest facility could operate at a cost of 36 cents per carton at 50 percent capacity. None of the three smaller CA units would be profitable when operated at less than capacity if the increase in prices were less than 35 cents per carton. Regular storage costs range from 20 cents at 40,000- and 80,000-carton houses at 100 percent capacity to 31 cents per carton for the 10,000- and 20,000-carton houses at 50 percent capacity.

For certain storage decisions, it is useful to separate costs that vary with volume stored from the costs that are independent of volume. For example, variable or operating costs such as labor and electricity expenses increase as volume stored increases. These expenses would not be incurred if apples were not stored. Labor expenses are associated with placing in and removing apples from storage. Overhead costs associated with buildings and equipment, on the other hand, do not vary with the volume stored if the investment has already been made. These costs would be incurred in any given year regardless of the quantity stored. Hence, a decision to store or not to store and how long to store is influenced by whether the investment in storage facilities has already been made and whether the fruit has already been placed in storage during any particular year.

All-Costs Variable

North Carolina producers generally are in a situation where the investment in storage facilities has not been made. Thus, all costs are of a variable nature and both overhead and operating costs must be considered in evaluating the feasibility of apple storage. Average monthly costs for four sizes of operations were estimated by assuming that storage costs are incurred equally by month.¹³ These monthly costs assuming a storage period of five months for regular and seven months for CA storage are presented in Table 2.

¹²Storage costs were estimated on a per carton basis. The weight of apples per carton ranges from 37-44 pounds. There are 48 pounds of apples per bushel.

¹³In reality, costs would be slightly higher during the months in which apples are placed in storage and when they are taken out due to increased labor costs. However, it was not felt that this difference was large enough to warrant the estimation of costs for individual months.

Table 2. Average total monthly costs of storing apples beginning in August by size of house and type of storage at three capacity levels using a non-pallet method

Size of operation (1,000 cartons)	Level of operation (percent of capacity)		
	50	75	100
(cents per carton per month)			
Regular storage ^a			
10	6.2	5.4	4.4
20	6.2	5.2	4.2
40	5.8	5.0	4.0
80	5.6	4.8	4.0
Controlled atmosphere storage ^b			
10	7.6	6.3	5.0
20	6.0	5.3	3.9
40	6.0	5.0	4.0
80	4.1	4.3	3.4

^a Assumes a storage period of five months.

^b Assumes a storage period of seven months.

Source: Gene A. Mathia, Costs of Storing North Carolina Apples, Department of Economics, Econ. Info. Report 5, N. C. State University at Raleigh, 1967.

Although total storage costs were higher for CA facilities, average monthly costs were generally lower except for the smallest size storage facility. Average costs per month varied less than 1 cent per carton per month for both regular and CA storage with an average of about 4 cents per carton per month when the three larger units were operated at 100 percent capacity.

Storage Facilities Available

Investment (overhead) costs have no influence on the decision to store once the investment in storage facilities has been incurred. Costs of operating various sizes and types of storage houses are presented in Table 3. These are the relevant costs in assessing the feasibility of storage in any given year for the producer who has storage facilities available.

Total operating costs per season associated with a 40,000-carton house were estimated at 11 and 14 cents per carton for regular and CA storage, respectively, when considering a storage period of five months for regular and seven months for CA storage. Monthly average costs of operating both types of storage houses varied from a low of 1.8 cents per carton in the 80,000-carton controlled atmosphere house to 2.6 cents per carton per month in a 10,000-carton regular storage house. Losses of fruit due to disease, rodents, etc., were not included in these estimates.

Table 3. Variable or operating costs of storing apples beginning in August by size of house and type of storage using a non-pallet method

Size of operation	Regular storage costs ^a		Controlled atmosphere storage costs ^a	
	Operating cost per season	Average operating cost per month	Operating cost per season	Average operating cost per month
(1,000 cartons)	(cents/carton)	(cents/carton) ^b	(cents/carton)	(cents/carton) ^b
10	12.9	2.6	16.6	2.4
20	11.5	2.3	13.5	1.9
40	11.0	2.2	14.1	2.0
80	10.8	2.2	12.8	1.8

^a Assumes a five-month storage period for regular and a seven-month period for controlled atmosphere.

^b Assumes an equal distribution of costs by month. This procedure slightly underestimates average operating costs the first two or three months but overestimates average operating costs the last two to four months.

Source: Gene A. Mathia, Costs of Storing North Carolina Apples, Department of Economics, Econ. Info. Report 5, N. C. State University at Raleigh, 1967.

THE DEMAND MODEL

Price Pattern

Information about seasonal demand is required in determining the most profitable quantity of apples to store and the optimal rate of movement from storage. The purpose of this section is to estimate the relationship between price and quantity of apple shipments to the market area which North Carolina serves from August to March. This relationship provides useful information for evaluating the profitability of storage and for specifying the optimum market allocation over time.

The storage decision is made at the individual firm level. In most cases, the quantity of the product which a single firm sells does not significantly affect the price of the product. However, there is a price pattern facing apple producers and shippers during the harvesting and marketing season which is determined by forces beyond the control of individuals.

In any given season, a North Carolina producer can expect to face a monthly price pattern similar to that illustrated in Figure 2. For example, high early season prices are expected during August and September. As the apple harvesting season progresses, fresh market prices would decline as illustrated by prices in October and November. However, as the harvesting season draws to a close, prices begin to increase as apples are shipped from storage. Prices of apples coming from storage generally vary directly with the length of the storage period. The months of December to February represent the period in which apples are taken out of regular (and in some cases CA storage) and prices during this period gradually increase. Beyond February, however, apples are taken out of CA storage with only a few coming from regular storage.

A difference between the price at harvest and price of apples coming out of storage represents the gross return to the storage operation. Gross returns from storing North Carolina apples in regular storage facilities would be the difference between August and September

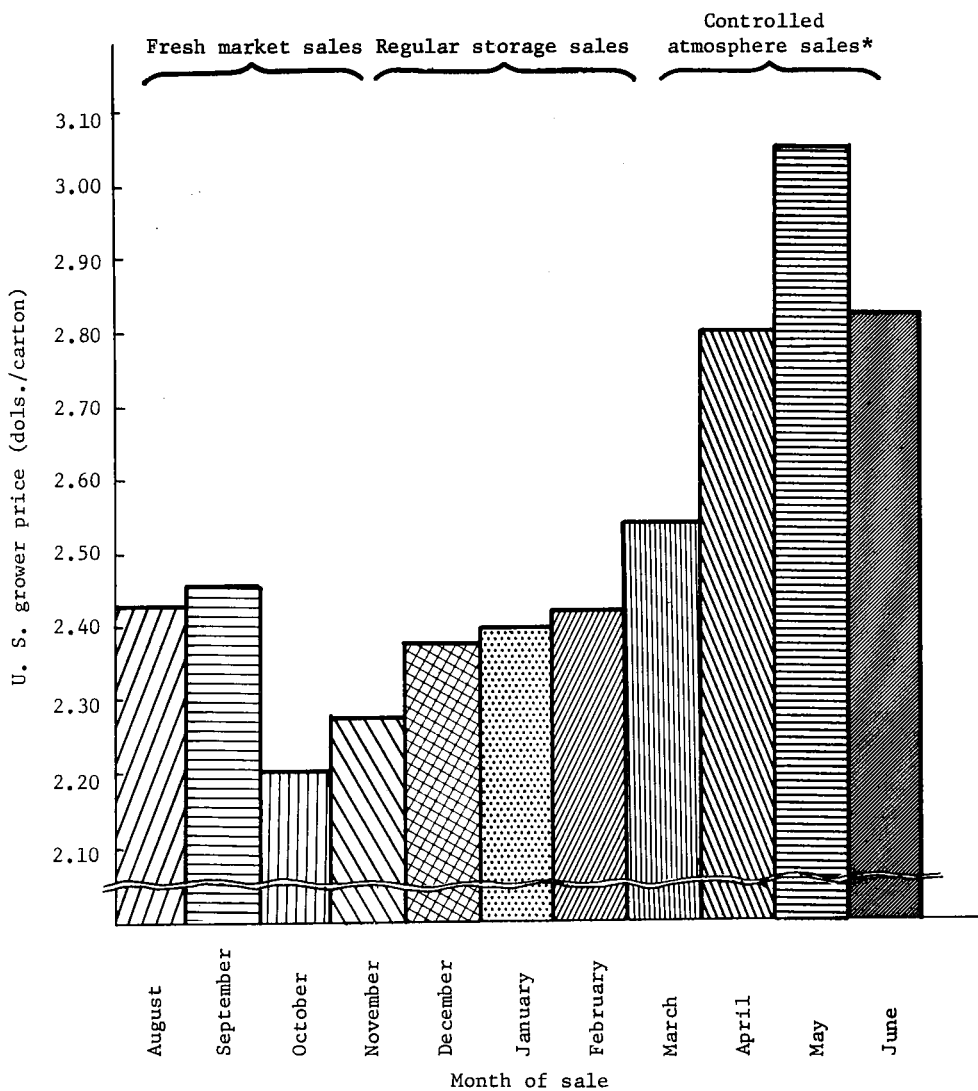


Figure 2. Average U. S. grower price for apples during the period 1956-1966

*Prices in May and June may be affected by sales of apples from the new crop.

Source: Statistical Reporting Service, U. S. Department of Agriculture.

price levels and December-January price levels. The differences between August and September price levels and the February and March price levels would represent gross returns to CA storage, assuming that North Carolina stored apples compete favorably with apples from other producing areas. As indicated previously, there are presently no CA apple storage facilities in North Carolina.

The price pattern observed by an individual firm is determined by the joint action of all firms in the industry. There are several factors generally recognized as influencing apple prices. These include volume of production, carry-over of processed apples, consumer income, consumption patterns, population, and prices of competing fruits. Pasour found that volume of apples produced in other eastern states has a statistically significant effect in explaining changes in North Carolina average farm prices when demand for North Carolina apples was estimated using annual data.¹⁴ No measure of the effects of consumer income or quantity of competing fruits on apple prices could be determined.

North Carolina is not an important state in storage of apples. Thus, North Carolina prices and quantities were not considered to be reliable indicators of demand conditions in the North Carolina market area (as previously defined). Carry-over stocks of processed apples were not included as a variable due to the lack of these data for the market area to which North Carolina ships apples. Quantity has been shown to be the most important variable and explains a large part of the variation in prices nationally.

The Model

The level of demand may shift from year to year depending upon changes in consumer income, population, competing fruits, carry-over stocks of processed apples, etc. However, in view of the poor quality and quantity of monthly data for these demand shifter variables, the analysis was restricted to data on monthly prices and quantities of apples. Zero-one variables were used (as explained below) to measure

¹⁴E. C. Pasour, Jr., Production, Marketing and Prices of North Carolina Apples, 1957-1963, A. E. Information Series No. 117, Dept. of Economics, N. C. State University at Raleigh, March 1965.

shifts in the level of demand from year to year. The relationship between monthly prices and monthly quantities is specified in the following model:¹⁵

$$(1) \quad Y_{mt} = a + b_1 Q_{mt} + b_2 X_1 + b_3 X_2 + b_4 X_3 + b_5 X_4 + b_6 X_5 + b_7 X_6 + b_8 X_7 \\ + b_9 X_8 + b_{10} X_9 + b_{11} X_{10} + b_{12} Z_{1t} + b_{13} Z_{2t} + b_{14} Z_{3t} + b_{15} Z_{4t} \\ + b_{16} Z_{5t} + b_{17} Z_{6t} + b_{18} Z_{7t} + u$$

where: Y_{mt} = price of apples for month m and year t at the farm level.

Q_{mt} = apple unloads (820 cartons per carload) from all sources to the North Carolina market area from August to March of year t .

X_1 to X_{10} = zero-one shift variables used to measure the yearly variation in the level of demand from the base year.

Z_{1t} to Z_{7t} = zero-one shift variables used to measure the monthly variation in the level of demand from the base month.

u = error term.

Shifts are permitted in the intercept but not the slope of the demand function. The variables X_1 to X_{10} were included to account for year-to-year changes in the level of demand. These shift variables permit changes in the level of demand from year to year while holding the regression coefficient constant. Variables X_1 to X_{10} take on values of zero or one depending upon the year which a particular observation represents. The yearly shift variables, X_1 to X_{10} , assume the value of zero for all months when 1956, the base year, is considered. For every month (m) of a given marketing year (t), X_t has a value of one while all other yearly shift variables assume a value of zero.¹⁶ For example, X_1 represents the 1957 marketing season. Hence, X_1 equals one and X_2 to X_{10} equal zero for each month of the 1957 marketing season.

¹⁵ A similar approach was used by Gallasch to study quantity-price relationships for Washington apples in the New York market. See H. F. Gallasch, Jr., "A Quantity-Price Relationship and Marketing Study for Washington Apples in New York Markets, 1960-65," unpublished paper, Dept. of Economics, N. C. State University at Raleigh, May 1967.

¹⁶ A discussion of the zero-one estimating procedure is presented by William G. Tomek, "Using Zero-One Variables with Time Series Data in Regression Analysis," Journal of Farm Economics, 45(4), November 1963.

Variables Z_{1t} to Z_{7t} take on values of zero or one depending upon the month which a particular observation represents. All monthly shift variables, Z_{1t} to Z_{7t} , assume the value of zero when August, the base month, is considered. In any month (m) of year (t) for the months September–March, Z_{mt} has a value of one while the other shift variables assume a zero value. For example, Z_{1t} represents the month of September. When September is considered, Z_{1t} equals one and the variables Z_{2t} to Z_{7t} equal zero. These shift variables allow changes in the level of demand from month to month while holding the regression coefficient constant.

Elasticities of demand for the various months of the marketing season can be determined from results provided by fitting this model to price–quantity data. Changes in demand elasticities during the marketing season can result from a change in slope or level (or, some combination of the two) or from a move along the demand curve. Initially, attempts were made to permit changes in slope as well as level of demand by dividing the marketing seasons into periods and estimating price–quantity relationships by period. However, an acceptable modification of the model to obtain the demand by period was not developed since the model contained no variable(s) to account for year-to-year shifts in demand.

Sources of Data

Empirical estimation of price–quantity relationships requires price and quantity data by months. The price series used was the average monthly U. S. grower price published by the U. S. Department of Agriculture.¹⁷ This is a blend price which is taken to represent all grades and varieties of apples sold on the fresh market.

Unload data are compiled by the U. S. Department of Agriculture on apples moving into major apple markets throughout the United States by state of origin.¹⁸ Since storage of North Carolina apples is of major

¹⁷U. S. Department of Agriculture, Noncitrus Fruit Prices, Supplement No. 1 to Agricultural Prices, various issues.

¹⁸U. S. Department of Agriculture, AMS, Fruit and Vegetable Division, Fresh Fruit and Vegetable Unloads--by Commodities, States.

concern, data on the quantity of fresh apples shipped from all supply areas by month for several years were compiled for 29 cities.¹⁹ These 29 cities received North Carolina apples sometime during the 1956-1966 time period.²⁰ Data are available by both rail and truck shipments, but aggregate unloads from all sources to the North Carolina market area were utilized in estimating the relationship between farm price and unloads.²¹

Unload data provide a measure of the volume of apple sales by month--both for North Carolina apples and for apples produced in other areas. The quantity of unloads and total volume marketed are not of the same magnitude since not all apple shipments are included in the unload statistics. For example, quantity of apples marketed for consumption in North Carolina or for cities not included in the 29 cities (within the North Carolina market area) is not known. Furthermore, shipments represented by the unload statistics are not likely to represent the same proportion of total sales over time. During harvest and the early marketing season, a lower proportion of total marketings may be included in the unload figures than may be the case when all apple sales come from storage. Consequently, the demand equation derived in the following section should be viewed as the relationship between price and unloads to the 29-city market area rather than the relationship between price and total apple sales.

In the following section price is assumed to be the dependent variable in estimating the relationship between price and quantity. It is not clear, however, whether price or quantity should more properly be considered as the dependent variable.

¹⁹The 29 cities were Atlanta, Baltimore, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Columbia, Dallas, Detroit, Fort Worth, Houston, Indianapolis, Kansas City, Louisville, Memphis, Minneapolis-St. Paul, Miami, Milwaukee, Nashville, New Orleans, New York, Philadelphia, Pittsburgh, San Antonio, St. Louis, Washington, D. C., and Wichita.

²⁰Any particular year referred to throughout this report pertains to the year of production and the marketing period for that crop. Each apple marketing year or season was assumed to begin in August and extend through the following March in North Carolina.

²¹Preliminary attempts to estimate the relationship between N. C. price and unloads from N. C. to the 29-city market area were unsuccessful.

Results of Analysis

Results of the model when fitted to the data for the period 1956-1966 by the least squares regression procedure were as follows:

$$\begin{aligned}
 (2) \quad Y_{mt} = & 2.72 - .00017Q_{mt} - .5938X_1 - .5052X_2 - .2568X_3 + .1424X_4 \\
 & t_b^{22} \quad (-2.27)** \quad (-5.37)** \quad (-4.58)** \quad (-2.49)** \quad (1.62)* \\
 & - .1463X_5 - .0170X_6 - .1358X_7 - .1161X_8 + .2311X_9 + .2213X_{10} \\
 & \quad (-1.67)* \quad (-.19) \quad (-1.49) \quad (-1.32) \quad (2.63)** \quad (2.48)** \\
 & + .3931Z_{1t} + .4222Z_{2t} + .3105Z_{3t} + .4600Z_{4t} + .3720Z_{5t} \\
 & \quad (2.12)** \quad (1.44) \quad (1.42) \quad (1.95)* \quad (1.96)* \\
 & + .3720Z_{6t} + .5497Z_{7t}; \quad R^2 = .82 \\
 & \quad (1.97)* \quad (2.77)**
 \end{aligned}$$

where: Y_{mt} = farm price of apples in dollars per carton for month m and year t .

Q_{mt} = quantity of apple carloads (820 cartons per carload) from all sources to the North Carolina market area for month m and year t .

X_1 to X_{10} = zero-one shift variables for years in which 1957 = X_1 , 1958 = X_2 , etc., which assume the value zero or one depending on the year considered.

Z_{1t} to Z_{7t} = zero-one shift variables for months September (Z_{1t}) to March (Z_{7t}) for year t which assume the value zero or one depending on the month considered.

The quantity and shift variables in equation (2) accounted for 82 percent of the price variation in the North Carolina apple market area during the period 1956-1966.²³ All the shift variables except for the years 1962, 1963 and 1964 (X_6 to X_8) and for the months of October and November (Z_{2t} and Z_{3t}) were significant at the 10 percent level and

²²A one-tailed t test was used to test the significance of the Q_{mt} coefficient and the two-tailed t test was used in testing all other variables. Coefficients were indicated as significant at the .10 level by one asterisk and at .05 level by two asterisks.

²³This is not strictly correct since the price series used represents a blend price for all U. S. apple sales and not just for apples sold in the North Carolina market area.

some were significant at the 5 percent level. These insignificant coefficients for the zero-one variables indicate that the average level of demand in 1962, 1963 and 1964 was not significantly different from the 1956 base, and that the level of demand in October and November was not significantly different from the August base.

The coefficient of Q_{mt} is the slope of the demand relationship and represents the change in the price of apples given a change in the quantity of apples marketed. This coefficient was significant and had the expected sign. It indicates that the price of apples (dollars per carton) declines by the amount of the coefficient (.00017) if an additional carload of apples is shipped to the North Carolina market area.

The coefficients associated with the shift variables (X_1 to X_{10} and Z_{1t} to Z_{7t}) provide estimates of the variation in demand by year or month from the August 1956 base. One can use these coefficients to determine the demand for any month of the marketing seasons for the years 1956-1966. The August demand is the following:

$$(3) \quad Y_{\text{August, 1956}} = 2.72 - .00017Q_{\text{August, 1956}}$$

How would one obtain the demand for, say, January of 1966? The August, 1956, equation must be adjusted by the 1966 shift coefficient ($X_{10} = .2213$) and the January shift coefficient ($Z_{5t} = .3720$). The January, 1966, demand would then be as follows:

$$(4) \quad Y_{\text{January, 1966}} = (2.72 + .2213 + .3720) - .00017Q_{\text{January, 1966}} \\ = 3.31 - .00017Q_{\text{January, 1956}}$$

It is interesting to note that the level of demand from September to March is higher than the August base for all months in which the coefficient is significant. This does not mean, however, that prices for apples during these months were necessarily higher than the August price. Since all the demand relationships have the same slope coefficient (-.00017), the price during the months September-March could be lower than the August price if monthly volume moving to the market is greater than for the base month even if demand is higher.

The highly significant coefficients for the yearly shifters indicate that changes in consumption patterns occur among years. The

positive and significant coefficients of X_4 , X_9 and X_{10} mean that there were upward shifts in demand (relative to 1956) during 1960, 1965, and 1966. Similarly, the negative and significant coefficients of X_1 , X_2 , X_3 and X_5 indicate that there were decreases in demand during the years 1957, 1958, 1959 and 1961. Yearly income differences, tastes and preferences along with availability and prices of substitute goods could aid in explaining year-to-year variation in the demand relationships.

The coefficient of Q_{mt} (-.00017) was used to calculate monthly elasticities using the average quantities and prices for the period 1956-1966. It was assumed that price elasticity is equal to the reciprocal of price flexibility. Elasticities in Table 4 were computed on the basis of unloads entering the North Carolina market area. Demand in each month was elastic (greater than absolute value of one). This indicates that a change in quantity of sales would not have a large effect on price. Elasticity for August was greater than for the other months which for the linear demand curve reflects a smaller average volume marketed during that month than in the other months.

Unload data used in the analysis do not represent the total quantity of total apples marketed. It is not known how elasticity estimates vary by months for total quantity sold. Data are not available regarding the proportion of unloads to total sales by month in the marketing area. One would expect monthly elasticities to be lower if total volume instead of unloads were considered since the responsiveness of sales to price changes depends upon the closeness of substitutes. The higher the proportion of apples included in the analysis, the poorer one might expect the substitutes to be.

Quantity measured by unloads is expected to be a fairly constant percentage of total apples marketed at all prices. It is expected also that unloads make up about the same percentage of total sales at high prices as for low prices although the proportion of unloads to total volume may be somewhat higher when apples are coming from storage.

Actual and estimated monthly prices for the 1964, 1965 and 1966 seasons are presented in Table 5 to test the predictability of the demand relationship. Predicted prices were derived from equation (2) using actual monthly unloads. Generally, equation (2) gave price

Table 4. Average monthly prices, unloads and price elasticities of demand for North Carolina and other states in the North Carolina market area, 1956-1966

Month	U. S. farm price (dols./carton)	Unloads			Elasticity
		N. C.	Other	Total	
		[carloads (820 cartons)]			
August	2.43	89.9	913.6	1003.5	-14.2
September	2.46	234.6	2948.4	3183.0	-4.5
October	2.21	163.3	4479.6	4642.9	-2.8
November	2.28	76.0	3568.6	3644.6	-3.7
December	2.38	45.3	3822.3	3867.6	-3.7
January	2.40	9.4	3233.8	3243.2	-4.4
February	2.42	8.5	3219.4	3227.9	-4.4
March	2.55	5.1	3353.1	3358.2	-4.5

Source: Statistical Reporting Service, U. S. Department of Agriculture.

Table 5. Actual and predicted monthly prices for 1964, 1965 and 1966 marketing seasons

Month	Prices					
	1964		1965		1966	
	Actual	Predicted	Actual	Predicted	Actual	Predicted
	(dols./carton)					
August	2.36	2.42	2.46	2.77	2.86	2.83
September	2.38	2.46	2.55	2.83	2.83	2.87
October	2.20	2.29	2.39	2.74	2.72	2.72
November	2.27	2.35	2.64	2.70	2.52	2.71
December	2.39	2.43	3.02	2.81	2.73	2.80
January	2.41	2.46	2.93	2.85	2.90	2.86
February	2.54	2.46	2.93	2.81	2.71	2.83
March	2.69	2.54	3.41	2.99	3.16	3.00

estimates for 1964, 1965 and 1966 which were somewhat higher than actual prices in the early months of the marketing season and lower than actual prices in the late months of the season. In the following section, actual price differences are used to draw implications regarding the profitability of storage.

OPTIMUM STORAGE CONDITIONS

Results of the two previous sections provide information for evaluating the profitability of storage by an individual firm. As stated previously, the individual firm makes the storage decision on the bases of (1) the expected seasonal price increase, and (2) costs of storage. The quantity stored or sold by the individual firm typically does not have a perceptible effect on price. However, if storage is profitable for one firm, it is likely to be profitable for many, and if all firms decide to take advantage of the apparent opportunity, quantity changes are likely to affect prices. In general, a large number of producers in the aggregate should expect prices and sales to vary inversely. In this study the quantity of apple shipments in the North Carolina market area was shown to be inversely related to price.

The following discussion describes the profitability of storing apples from the individual firm's point of view. A framework for evaluating storage opportunities is specified which assumes that prices are not affected by a firm's decision to store apples. Two situations are considered: (1) conditions necessary if storage facilities are not available, and (2) conditions necessary if facilities are available.

As discussed earlier, a firm decides to store apples if the following condition holds:

$$(5) \quad P_S \geq P_H + C_S$$

where: P_S = price of stored apples.

P_H = price of apples at harvest.

C_S = costs of storing apples.

Seasonal price differences ($P_S - P_H$) were calculated for apples stored in August, September and October and sold from September to March. Firms in North Carolina face the storage decision in late August and early September. However, firms in northern states with later harvesting seasons can make the decision as late as October and November. Once the apples are stored, a firm has to continually evaluate the

situation using the rule expressed by equation (5). That is, apples will be left in storage during any time period if the expected price increase is greater than the additional cost of storage.

The largest price difference for August stored apples during the 11-year period was 95 cents per carton which occurred in 1965 (Table 6).²⁴ Price differences between August and each of the months December, January and February were relatively large when compared with the same months in other years.

Costs of CA storage of apples for 7 months of storage were estimated to be about 30 to 35 cents per carton assuming 100 percent capacity in houses with more than 10,000-carton capacities (Table 1). This assumes the storage facilities are not available. Consequently, overhead as well as operating (variable) costs are relevant. For apples stored in August of 1964 and 1966, storage costs would exceed the difference between August and March prices. For apples stored in August of 1965, however, storage costs were less than the increase in price from August to December or January or February or March.

A table was prepared which summarizes the number of years storage was profitable assuming alternative months for placing apples in storage and selling from storage (Table 7). Investment in CA apple storage facilities for August storage and March sales would have been profitable five of the eleven years during the 11-year period, 1956-1966. It should be noted that North Carolina price in August is usually higher at the farm level than the U. S. farm price used for the analysis. This would reduce the margin of profitability for August storage if in fact the North Carolina August price is greater than the U. S. farm price.

The profitability of apple storage in September was slightly less favorable than in August. September CA storage for March sales was profitable during only three of the 11 years studied (Table 7). In Table 6, the largest price increase, 86 cents per carton, occurred between September and March of 1965. Differences of 31 and 33 cents

²⁴Price changes were calculated from the predicted prices presented in Table 5, but the monthly changes for most years were underestimated. Actual monthly prices were higher and the range in price from August to March was greater for these years than indicated by equation (2).

[illegible]

Table 6 (continued)

Source: Derived from data provided by the Statistical Reporting Service, U. S. Department of Agriculture.

Table 7. Number of years in which the seasonal price increase was greater than total storage costs during the 11-year period, 1956-1966

Method of storage	Number of years storage was profitable if sales were made in ^a						
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
<u>Controlled atmosphere</u>							
August	0	0	0	2	2	3	5
September	0	0	0	1	1	1	3
October	0	0	1	2	3	5	8
<u>Regular storage</u>							
August	1	0	0	2	3	b	b
September	0	0	0	1	1	1	b
October	0	0	2	3	3	6	10

^aStorage was considered profitable if the seasonal price increase exceeded 30 cents per carton cost of CA storage and 25 cents per carton for regular storage assuming that storage facilities are not available.

^bA five-month storage period was considered the maximum time in which apple quality could be satisfactorily maintained in regular storage.

per carton were observed for 1964 and 1966, respectively. Investment in facilities for September storage would have been profitable in 1965 but not very favorable in 1964 or 1966. The probability of having a favorable year (price increase greater than storage costs) is relatively low for September storage. Under such conditions, it would not appear to be generally profitable for an individual firm to make an investment in storage facilities to store in September. Investment in storage may be profitable although favorable conditions do not exist every year. However, favorable price differences during good years would have to more than offset the losses resulting in unfavorable years. Table 6 provides information which shows the absolute amount of the price differences for any given month during the 11-year period.

In northern states the apple storage decision is made in October in most cases. In Table 6, price differences (based on October prices)

are positive for each month beyond October in 1964 and 1965. The price increase was 102 cents per carton between October and March of 1965. Since overhead and operating costs of CA storage at 100 percent capacity vary from 24 to 35 cents per carton (Table 1) for different size facilities, storage for an individual firm would have been profitable. October CA storage for March sales was profitable in 8 of the 11 years during the 11-year period (Table 7). Of course, if facilities are available, storage in October is even more profitable for any given year since operating costs are then the only relevant costs. October storage by North Carolina producers is not a feasible alternative because of the early maturity date in the state.

Now consider the situation in which the investment in storage facilities has already been made. In this case, the criterion for storage is that the price increase must be greater than operating costs. Operating costs per month were estimated in a previous section. Two cents per carton per month was used as an estimate of operating costs for CA houses having a capacity of at least 10,000 cartons. Three cents per carton per month was used to compare the storage costs with price differences in regular storage.

The years in which operating costs of CA and regular storage facilities were less than the observed price difference are presented in Table 8. Price differences for October CA storage and March sales were greater than operating costs for 10 of the 11 years studied. Apples could be profitably stored during 9 of the 11 years for both December and January sales if CA facilities were available.

Operating costs of regular storage were less than the observed price differences for 10 of the 11 years if apples were stored in October and sold in March. August storage in regular storage facilities was not as favorable as October storage. The price increase would have exceeded operating costs of storage during only 4 of the 11 years if apples were sold in January. Here again, it should be noted that the average farm price of North Carolina apples in August is usually greater than the U. S. August farm price. Higher August prices would lower the price difference and adversely affect the profitability of apple storage.

Table 8. Number of years in which seasonal price increase was greater than operating costs for storage during the 11-year period, 1956-1966

Method of storage	Number of years in which storage was profitable if sales were made in ^a						
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
<u>Controlled atmosphere</u>							
August	6	1	3	4	4	5	6
September	0	0	2	3	3	4	7
October	0	0	7	9	9	8	10
<u>Regular storage</u>							
August	5	1	3	4	4	b	b
September	0	0	1	2	2	4	b
October	0	0	7	9	9	8	10

^aStorage was considered profitable if seasonal price increase exceeded 2 cents per carton per month for operating available CA storage facilities and 3 cents per carton per month for operating available regular storage facilities.

^bA five-month storage period was considered the maximum time in which apple quality could be satisfactorily maintained in regular storage.

CONCLUSIONS

The profitability of storing apples depends on the costs of storage and the difference between the price of apples at harvest and the price of apples when removed from storage. The seasonal price increase depends on the size of the crop and quantity of apples stored. Costs of storage facing an individual firm depend on the size, type and availability of facilities along with the length of storage period. The major objectives of this study were to (1) determine the responsiveness of price to changes in apple sales during various periods of the marketing season in the North Carolina apple market and (2) provide information to the North Carolina apple industry on the profitability of investing in new apple storage facilities or using facilities already in existence.

Results of this study suggest that the demand for apples in the North Carolina apple market is quite elastic early in the marketing season. If demand is, in fact, quite elastic, it means that neither increasing the quantity stored nor selling increased quantities on the fresh market is likely to have a large impact on price during the harvest period.

North Carolina Red and Yellow Delicious varieties of apples are placed in storage in August and September and are sold from October to March. These same varieties are stored much later in major northern producing states. The results of this study indicated that the seasonal price increase of apples stored in August and sold in March exceeded the total cost of apples stored in CA facilities only 5 of 11 years during the 1956-1966 period. October storage in CA facilities for March sales was profitable (total storage costs were less than the price increase) in 8 of the 11 years studied.

The quality of apples stored in regular storage facilities in August or September cannot usually be satisfactorily maintained until March. The seasonal price increase from August to January exceeded the total costs of regular storage during only 3 of the 11 years studied. In 5 of the 11 years, the August price actually exceeded the January price.

Apple storage for any given year is more profitable in either type of storage house if facilities are available. The seasonal price increase of apples stored in either regular or CA facilities in October and sold in March exceeded the operating costs during 10 of the 11 years studied. March sales of CA apples stored in August were also profitable during 6 of the 11 years.

Regular storage (assuming storage facilities were available) in August was not as profitable as storage in CA facilities. The price increase from August to January was greater than operating cost (12 cents per carton) in regular facilities in only 4 of the 11 years. In these years, the price differences did not greatly exceed operating costs and in other years the price difference was actually negative.

Many unanswered questions remain concerning the most profitable marketing outlets for North Carolina apples. Reserving the better quality fruit for storage may have an adverse effect on returns to early fresh-market sales. Further research is needed to determine how returns to the total crop would be affected by increased storage.

Returns to storage may be greater than indicated by this study if the quality of North Carolina apples can be satisfactorily maintained for a period longer than August to March. Sales of apples in April and May might be profitable if the quality problem can be solved. Further work on the physical and economic factors associated with quality is anticipated.

The feasibility of additional processing facilities is currently being evaluated. Also, investment in a joint storage-processing operation may be profitable whereas either considered separately could be unprofitable. The storage operation could increase the length of the processing period as well as the total quantity processed. This joint investment problem is under investigation.

Marketing larger quantities in the cities currently receiving North Carolina apples may not be as profitable as expanding the marketing area geographically. A study is currently under way to determine the most profitable markets. Of course, expansion of the geographic market area for early fresh market sales has important implication for both stored and processed apples. Valuable marketing ties with wholesalers and brokers established during the early fresh market period could mean marketing contacts for stored and processed apples.

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