LOSSES IN U.S. FOOD DISTRIBUTION SYSTEM

PRODUCE
(Fresh Fruits & Vegetables)
LOSSES

Thomas R. Pierson
John W. Allen
Edward W. McLaughlin

Department of
Agricultural Economics
MICHIGAN STATE
UNIVERSITY
East Lansing

Agricultural
Economics
Report 422

December 1982

PRODUCE LOSSES IN THE U.S. FOOD DISTRIBUTION SYSTEM

Thomas R. Pierson

John W. Allen

Edward W. McLaughlin

Agricultural Economics Report 422
Michigan Agricultural Experiment Station Journal Article 10877

Department of Agricultural Economics
Michigan State University
East Lansing, Michigan
December, 1982

PREFACE

This is one of eight reports resulting from a study of losses and waste in food distribution. The National Science Foundation-Research Applied to National Needs (NSF-RANN) commissioned and provided primary funding for the analysis of the general magnitudes and locations of food losses occurring in the U.S. food distribution system. Additional resources were provided by Michigan State University's Agricultural Experiment Station and Cooperative Extension Service. Seven food product categories have been analyzed: fresh beef, produce, dairy products, dry grocery, frozen foods, bakery goods, and foods sold through delicatessen departments. Foods within these categories constitute about 92 percent of supermarket dollar food sales. Dry grocery is the largest category, accounting for about 36 percent of supermarket food sales. It is followed by dairy products at about 15 percent, fresh beef at about 13 percent, and produce at about 9.8 percent of food sales. Frozen foods, "deli" department foods, and bakery goods accounted for 8.1, 5.2, and 4.7 percent, respectively. It should be noted that with the exception of fresh beef, the categories are designated according to conventional food store departments. In the case of beef, it is the dominant product in the meat department.

This particular report contains: an introduction and orientation to produce distribution through supermarkets; a discussion of the general nature of produce losses; and findings of the magnitudes, causes, and suggested remedies for produce losses. The following companion reports also derived from the NSF-RANN study complement this report:

- Losses in the U.S. Food Distribution System
- Fresh Beef Losses in the U.S. Food Distribution System
- Dairy Product Losses in the U.S. Food Distribution System
- Dry Grocery Losses in the U.S. Food Distribution System
- Frozen Food Losses in the U.S. Food Distribution System
- Bakery Losses in the U.S. Food Distribution System
- Delicatessen Food Losses in the U.S. Food Distribution System

PRODUCE LOSSES IN THE U.S. FOOD DISTRIBUTION SYSTEM*

CONTENTS

*In addition to the principal authors, major contributions to this report were made by Susan E. Karony, Research Assistant, Department of Agricultural Economics, MSU, and James L. Brock, Graduate Assistant, Department of Marketing and Transportation Administration, MSU.

INTRODUCTION

The reality of serious resource shortages coupled with stagnant productivity over the past decade has led to a renewed search for ways to improve efficiency in the U.S. economy. The productivity problem and resource shortages have been important factors in creating the nation's most serious economic problem--inflation. Among the most visible symptoms of inflation are rising gasoline and heating fuel costs as well as food price increases. Rapid food price increases and the hardships they pose for society highlight the necessity to improve productivity and resource utilization in the food distribution system. Among the many resources used in the distribution of foods--labor, energy and capital, to name just a few--food itself must be included as a vital resource. Thus, food firms need to develop and implement more "food efficient" distribution methods within an overall context of cost efficiency.

At the present time, however, the nature of food losses in the distribution system is often not well understood. Neither the magnitudes nor the locations of food losses have been adequately documented. Even definitions of the terms differ greatly. Nonetheless, until the magnitudes and locations of the losses are established, opportunities to take action to reduce them are severely limited. This report presents preliminary estimates of fruit and vegetable losses in the U.S. produce distribution system.

The Nature of the Research

"Produce losses" is a term subject to many interpretations. The purposes and nature of this study dictated the use of a number of different "produce losses" terms and concepts: (1) losses by weight, (2) economic value of physical losses, (3) total economic costs associated with losses, (4) shrinkage, and (5) losses resulting in reductions of either the quantity or quality of produce available for human consumption. Although different "produce loss" concepts with disparate data were used, the study tended toward a single focus: an effort to develop estimates or proxies for the quantities of produce lost for human consumption.

Losses of produce available for human consumption refer to those products commonly distributed through the contemporary marketing and distribution systems. Thus, products which are customarily and purposely discarded, such as retail produce trimmings, have not been included as losses, even though they may be edible and nutritious.

The project covered produce distribution activities ranging from the packer's or processor's shipping dock through transportation, wholesaling and supermarket retailing operations. Clearly, depending upon the product, these operations vary sharply from one another. Lettuce, for example, may be packed for shipping immediately after harvest while still in the field. Thus, losses of lettuce were calculated from the time it left the field until consumers purchased it in supermarkets. On the other hand, fresh apple losses were estimated from the time they left the packing shed until consumers purchased them in supermarkets. In all cases, the distribution systems covered in the study were those ending with the supermarket, and most often they began with transportation to distribution centers or warehouses which service supermarkets. In essence, the vast majority of transportation, wholesaling and supermarket retailing activities of fruit and vegetable products were included for study.

The specific objectives of the study were:

-- To identify the general magnitudes and locations of major produce losses during distribution activities based upon a thorough inventory of available information.

-- To determine the approaches currently used to control produce losses, and to assess the strengths and weaknesses of these approaches.

-- To identify produce loss issues which may need additional research in order to reduce losses.

Research procedures employed to achieve these objectives involved a four-step process:

-- An initial, broad-based survey of published information was conducted. Sources of information included: (a) university, United States Department of Agriculture, and private industry-sponsored research studies; (b) proceedings of university and industry-sponsored symposia on food losses and related topics; and (c) trade publications.

-- A select panel composed of representatives from industry, trade associations, and government met at Michigan State University to review and comment upon the preliminary findings. They also contributed to the identification of comprehensive resource materials.

-- The analysis and synthesis of selected published data was conducted in order to develop a comprehensive picture of produce losses.

-- A limited number of in-depth interviews were carried out with selected industry authorities to provide additional information, and to ascertain the reasonableness of findings.

Produce Distribution

In 1977, consumers expended approximately $9.5 billion for purchases of fresh produce in supermarkets. This represented about 9.8 percent of supermarket food sales (7). Following a decline since World War II, per capita consumption of fresh fruits and vegetables in recent years has shown signs of increasing. Americans consumed an estimated annual per capita average of 102.0 pounds of fresh vegetables (excluding potatoes) during the 1975-1977 period, an increase of about 3.1 percent above comparable figures for the 1970-1972 period. Similarly, per capita fresh fruit consumption (citrus and non-citrus) increased by about 6.5 percent to an annual average of 84.6 pounds during the 1975-1977 period. This is compared with 79.4 pounds per year during the 1970-1972 period (68).

The apparent renewed consumer interest in produce coupled with the highly perishable nature of these products underscores the importance of this study of losses. The inherent perishability of produce, as well as the additional causal factors discussed in this report, result in relatively large losses during the distribution processes.

To facilitate the study, research efforts concentrated on, but were not limited to, 15 important produce items which constitute about 81 percent of supermarket produce department sales (6). These items and their shares of supermarket sales are shown in Table 1.

Table 1. Major Produce Items Studied

Produce Item	Produce Department Sales
	(percent)
Citrus	11.21
Potatoes	10.98
Tomatoes	8.77
Bananas	8.51
Lettuce	8.23
Apples	7.40
Melons	6.31
Dry Onions	3.77
Berries	3.64
Grapes	2.62
Celery	2.46
Cabbage	2.14
Carrots	2.12
Peaches	1.73
Cucumbers	1.36
Total	81.25

Source: See (6)

GENERAL NATURE AND CAUSES OF PRODUCE LOSSES

Produce losses vary greatly in magnitude, as well as in kind. Some losses of produce are so blatantly obvious, as to require their immediate removal from the distribution system. Other losses are of a more subtle kind and are more difficult to detect and measure. Such losses are reflected in reductions from peak quality taste, appearance, and even nutritional content. They may or may not contribute to reduced life of product in the distribution channel or on supermarket display racks. With respect to nutrient losses, one study found that inadequate temperature and humidity conditions caused losses of Vitamin C and A in certain products; and that the amount of losses varied by commodity, and length of storage. It may be of interest to note that some fruits and vegetables, those comparatively more resistant to the harsh treatment of distribution functions, may have been substituted over time for the less hardy--though more nutritious--varieties. For example, specialty lettuce, such as Romaine, Red, or Butter lettuce, are much more fragile in distribution and have shorter shelf lives than Iceberg lettuce, but they contain approximately five times the vitamins.

In general, a large proportion of produce losses results from the interaction of several factors: inadequate temperature and humidity; improper packaging and handling; slow product movement and unexpected reductions in market demand; government regulations, or lack thereof; the inherent short product life of many produce items; trim and spoilage; excessive moisture evaporation; and poor quality product entering distribution. Several of these factors are described below.

Temperature and Humidity

The inadequacy of temperature and humidity is a problem prevalent throughout the entire produce distribution system. Since most produce items have narrow temperature tolerance ranges (normally 10-15^{O} F.), it is a critical factor in quality maintenance. As a rule, the respiration rate of fresh produce doubles for approximately each 18^{O} F. rise in temperature above 32^{O} F. Cabbage, for example, will retain its high quality for over six weeks at 32-38^{O} F.; however, when the temperature rises to 45^{O} F., shelf life is reduced to a maximum of four weeks (50). Similarly, apples stored one day at 70^{O} F. incur as much deterioration as in ten days at 30^{O} F. Appendix I shows the optimal holding temperature ranges for many kinds of fresh fruits and vegetables.

The most direct effect of inadequate temperature and humidity conditions is the increased rate of moisture loss, causing weight reduction of the product. Since produce is often sold by the pound, weight loss directly reduces its monetary value in the marketplace. Moisture loss may also cause losses of nutritional content, flavor and appearance. Losses of this kind that exceed 10 percent of a given product's weight typically cause severe wilt in many fruits and vegetables. A few commodities, however, may lose more than 10 percent moisture and retain their saleability if properly trimmed (65).

In an effort to resolve the temperature problem, industry researchers have been experimenting with time-temperature recorders which show temperature variations experienced by products as they move through the distribution system. Recorders are placed with shipments to monitor temperatures, yielding information which could have the positive effect of reducing losses by increasing awareness of the exact situations under which temperature problems occur.

Physical Handling

Improper handling is another damage-causing problem that occurs throughout the distribution system. Abusive treatment of products is due principally to a lack of training and supervision of personnel who are involved in the handling of fresh produce. They either fail to appreciate the fragile nature of produce and the losses which result from rough treatment; or they simply do not act in accordance with this knowledge.

Excessive physical handling also contributes to produce losses. A 1976 report indicated that lettuce, for example, sustained an average handling loss of two heads per 24-count box. Approximately 100 million boxes of lettuce, valued about $9.00 per box, were shipped annually (6). Extending these figures results in losses of about 8.3 million boxes, valued at nearly $75 million.

Trim loss is yet another problem related to physical handling. It is interesting to note that losses resulting from trim are almost exclusively associated with vegetables where, in many instances, outer leaves if left intact act as a protective covering. However, when the outer leaves are removed to improve appearance, deterioration may be accelerated. Fruits, on the other hand, generally are not trimmed; thus bruises and cuts most frequently result in loss of the entire item.

Packaging

The role of packaging in produce losses is complex. Products are damaged most typically when shipping containers are collapsed, crushed or come open during harsh handling. These problems are associated not only with package design and materials, but also with handling methods, and the temperature and humidity environment to which the package is exposed during distribution. Many package sizes do not fit the standard 48" x 40" pallet base without either excessive package overhang or underutilized pallet space. Many containers are designed such that stable, or unitized pallet loads of products for efficient handling cannot be achieved. The difficulty of stacking containers into unitized pallet loads is compounded when mixed loads of produce are assembled for shipment. These and other packaging-related problems could be reduced substantially through the use of modular designed shipping containers--that is, package sizes and shapes designed to permit stable, interlocking stacking of containers on an industry-wide standard pallet base.

Initial Product Quality

It is important to note that the quality of produce as it initially enters the distribution system has a significant impact on the quality of the product leaving the system when marketed to consumers. Quality cannot be improved as produce moves through the distribution system! Deterioration, even under ideal conditions, is an inevitable continuing process. Thus, a major objective of the produce distribution system must be to minimize quantity and quality losses in balance with the economic realities of the marketplace. In this respect, influence over produce waste and losses is in large part a function of economics. For example, when lettuce prices are relatively high, a larger than normal proportion of all lettuce is harvested, packed and shipped. This introduces into the distribution system a larger proportion of lettuce which is of marginal quality. This situation ultimately results in comparatively higher losses. By contrast, when lettuce prices are low, the quality of produce entering the distribution system tends to be high. Losses are relatively low in this situation, as a result of a large proportion of the crop (the lower quality lettuce) being left in the field.

Although produce experiences losses during each phase of the distribution channel, unless the "breaking" of bulk shipment for prepacking takes place at the wholesale level, losses occurring in the early phases of distribution may remain undiscovered until products reach the retail level. Thus, it is often difficult to ascertain the exact source or cause of produce losses. Prior to discussing produce losses in each of the several phases of distribution--transportation, wholesaling and retailing--a final observation should be made. A number of problems have been identified which frequently result in produce losses, such as inadequate temperature and humidity, improper handling, packaging failure, and so forth. When considering losses in produce, it is useful to bear in mind that these problems occur within a distribution system which functions as a result of not only biological factors (high perishability), but the economic, social and managerial realities of the produce distribution system.

LOSSES DURING TRANSPORTATION OPERATIONS -- PACKER TO WHOLESALER

Industry observers estimate that approximately 88 percent of all fresh fruit and vegetables were shipped to market by truck in 1978. The remaining 12 percent moved mostly by rail, and to a lesser extent by plane and ship. There seems to be a trend toward increasing the distribution of produce by air cargo--especially the most perishable, high value commodities such as strawberries and apricots. However, the most predominant trends in perishables' transportation are the continued increase in the use of trucks and the consequent decrease in the use of rail.

Magnitudes of Losses

There is no published record of the volume of current produce losses occurring in truck transportation. Produce commodities are exempt from Interstate Commerce Commission (ICC) reporting regulations, and thus, loss records are not maintained. Data on losses in transportation appeared in the 1965 Agriculture Handbook, "Losses in Agriculture;" however, truck and rail car losses were combined. In that study, fruits with the highest reported losses in dollar value (a function of both the loss rate and sales volume) were: apples, grapes, oranges, peaches and strawberries. With respect to vegetables, the largest losses were reported for: lettuce, potatoes, tomatoes and watermelon (58). More detailed data from the Handbook are shown in Appendices II and III.

Other information sources on transportation losses include reports from wholesale produce buyers and the Association of American Railroads (AAR). The AAR recorded dollar damage claims paid per \$100 of revenue. These figures pertain exclusively to railroad losses and damage; however, since total volume of shipments is not reported, produce losses as a percentage are unable to be calculated. Produce buyers for a major supermarket chain, which receives produce primarily by truck, reported that the firm rejects about 4 percent of the produce arriving at their distribution centers. Assuming that 100 percent of these shipments were saleable when they were shipped from the packing point, a 4 percent loss rate can be attributed to the transportation phase. Clearly, additional research is necessary to test this broad assumption.

Causes of Losses

When it is considered that the transportation phase may represent one-half or more of the packer-to-retailer time period, it can be appreciated that transportation has a substantial impact on produce losses (20). With respect to railroad losses, the largest single cause for damage claims was temperature failure. In 1975, temperature failure accounted for 53.0 percent of potato losses, 48.3 percent of fresh fruit losses, and 41.0 percent of fresh vegetable losses. Additional data relative to such losses are available in Appendix VI.

The temperature at which produce is held affects the rates of all biological processes--respiration, growth, ripening, moisture loss and the development of decay-causing organisms. A case in point is lettuce, which according to a 1967 study should be kept as close to 32^{0} F. as possible. Proper in-transit temperatures not only are essential to maintain optimum quality until time of arrival at the destination, but also prolong market life (shelf life) (60). The rate of lettuce respiration increases greatly as temperature increases; and the rate of deterioration increases by two to three times for each 18^{0} F. rise in temperature (15).

During transportation, packaging materials are subjected to considerable stress. In the AAR's statistics on freight loss and damage, packaging failure and improper handling are the major loss factors contributing to the "not otherwise accounted for" category, the third leading cause of losses (following temperature failure and delay) (see Appendix IV). As suggested by the AAR data, produce packaging does not always adequately protect its contents. For example, inadequate packaging materials were responsible for losses which resulted when potatoes packed in 50- and 100-pound burlap bags sustained "floor layer bruising" in rail cars. Although a totally effective material has not yet been developed, such losses can be reduced by cushioning with the use of excelsior pads, macerated paper-filled pads, or double-faced corrugated fiberboard.

Inadequate ventilation caused by containers which obstruct cold air flow around produce during transit is another frequently reported packaging problem. Lack of cold air circulation slows the cooling rate restricting the removal of produce respiration heat. Shippers currently attempt to cope with ventilation problems in a number of ways. Some shipping cartons are designed with ventilating holes, and pallets are constructed so as to permit air circulation through them. Refrigerated truck trailers are equipped with parallel, front-to-back floor channels to facilitate air movement. Moreover, proper loading practices leave an air space above the cargo, so that fresh, cold air can be circulated throughout the cargo during shipment.

The crushing of lower layer containers in stacks of produce is another packaging-related problem. This situation can be caused by any one of several factors:

- Container side walls do not support reasonable stacking weights.
- Containers are weakened by excessive moisture.
- Excess weight and stress are placed upon containers due to improper stacking or loading methods.
- Both "under filling" and "over filling" of containers can cause undue stress on lower layers of stacked cartons.

"Under filling," which leaves excessive head space in containers, tends to place the entire burden of weight from above upon container side walls with the contents bearing no load until substantial crushing occurs. "Over filling," in addition to causing some initial bruising during packing, frequently weakens the stacking strength of container side walls by causing them to bulge. Thus, contents are subjected to excessive load-carrying weights when stacked. For instance, Eastern-grown peaches were transported in jumble-filled boxes designed to hold 38-39 pounds of peaches. However, some shippers overfilled boxes for a favorable visual effect upon buyers at terminal markets. In a test study, it was found that overpacking the boxes by 4.3 pounds, to a range of 40.5-44.8 pounds, increased "slight bruising" from 1-10 percent, "moderate bruising" from 1-4 percent, and "serious bruising" from 0-2.5 percent (54).

Another cause of produce losses during the transportation phase is excessive delivery time from the field or packing shed to the distribution center. Transportation delays lead to reductions of shelf life at the retail level, creating higher losses. Problems associated with delivery delays, however, are compounded by uncertain delivery schedules. Unpredictable delays, coupled with uncertain delivery schedules, increase the difficulty of developing standardized procedures for the proper care and handling of produce at both the wholesale and retail levels.

Periodic truck shortages were also identified as an important causal factor for losses. Shortages are most noticeable among independent haulers--the majority of produce transporters. Recent truck shortages have prompted some shippers to switch to rail transportation even though rail service has deteriorated to the point that West Coast produce shipments may take up to two weeks or longer to reach Eastern destinations.

Loss Reduction Potentials

The use of unitized shipments with pallets or slip sheets together with package modularization would help considerably to reduce handling costs and product damage not only in transportation, but throughout the distribution system as well. Together, these practices would permit fast, mechanized handling and loading, and ensure delivery of produce with less damage than if individual cartons were handled several times during the distribution processes as is now so often the case. "Strapping" of pallet loads is an important component of improved handling. Use of this technique converts a stacked pallet load of shipping containers into a more stable single unit that can be shipped with much less risk of handling damage.

Greater attention needs to be devoted to the basic shipping container. To fulfill its role, it must provide stacking strength, be packed and closed properly, and be well ventilated. Although far less encompassing than an industry-wide system of modular packaging, improvements in individual produce packages hold substantial promise for loss reduction. Packages are needed that better protect produce from physical abuse and contaminants, and help to prevent deterioration in quality. For instance, Valencia oranges stored in polyethylene bags for four weeks at 41^{o} F. were in excellent condition, losing an average of only 1.7 percent in weight. This compared with a much higher weight loss for fruits stored in paper bags, 9.5 percent (35). In another study, Golden Delicious apples in traypacks with a polyethylene liner experienced a weight loss of about 1 percent, as compared to weight losses ranging from 4-7 percent using more traditional packaging (67). Washington Red Delicious apples packed in a pallet box had a proportion of sound apples of 72.5 percent, compared to 82.7 percent for similar apples packed in traypack cartons. Total bruises were also influenced by the kind of packaging employed. Nearly 33 percent of the apples shipped in pallet boxes were bruised; whereas, only 19.2 percent of those shipped in traypack boxes were bruised (63). Thus, packaging has a significant effect on weight loss, bruising, and the overall condition of many produce items.

In the process of moving toward a system of modular containers, standards must be set and containers should be designed to conform to a pallet base of uniform size. There are at present over 500 different container sizes, shapes and types used in shipping perishables--and several different pallet sizes. For unitized shipping to be successful, the number of sizes, shapes and types of containers should be reduced and standardized according to modular dimensions, and a single uniform pallet base size should be designated.

Industry cooperation in the development and implementation of standardized, modular shipping carton sizes would be a major step forward toward the reduction of food losses. Modular produce packaging would permit efficient construction of secure mixed pallet loads for transportation and handling throughout the distribution system. Retailers appear to have most at stake in the development of such positive changes; but, clearly, this development will require industry-wide cooperation and coordination.

Recent research has identified groups of fruits and vegetables which are compatible for mixed load shipments and storage. Compatibility is based upon the following types of factors:

- Temperature and humidity requirements
- Response to atmosphere modifications
- Need for protection from odors
- Need for protection from physiologically active gases
- Need for icing

Future utilization of this information in establishing practices for assembling mixed shipments, and in designing warehouses is expected to substantially reduce losses during transportation and in the storage phases of distribution. This information is reported in detail in Appendix I.

Improvement in transportation facilities and services will require an industry-wide effort, perhaps with trade association, university and government involvement. Among the alternative modes of produce transport, railroads, because of their relatively low cost per mile, appear to have much potential, especially for long-distance hauling. Railroads, however, pose the greatest problems with respect to rapid and dependable service. Thus, viewed from only a "transportation cost" perspective, truck transportation is used to excess relative to rail; however, shippers and buyers accept higher mileage costs placing greater value on more secure, dependable delivery of highly perishable produce commodities. As petroleum-based energy becomes relatively more costly, transportation-related problems will become still more critical in importance.

LOSSES DURING WHOLESALING OPERATIONS

In this section of the report, produce losses occurring during the wholesaling functions are explored. Activities most commonly included during wholesaling functions are: receiving at the distribution center, storage, selection, breaking of bulk shipments, and prepacking of produce prior to delivery to supermarkets. The techniques of performing wholesaling functions have undergone many changes in recent years. Included is the automation and mechanization of warehouse handling equipment, as well as improvement in wholesale level produce storage facilities. These advances are intended to offset the rapidly rising marketing costs, and improve service levels to supermarkets while maintaining quality of the produce.

Magnitudes and Causes of Losses

Studies have been conducted in the Chicago and New York markets which dealt with marketing losses of fruits and vegetables encountered at the wholesale level (61,62). Six key produce items were selected for study to determine the amounts of parasitic, non-parasitic and mechanical (physical) losses incurred in normal handling. Parasitic losses were defined as those caused by any type of parasite; non-parasitic losses were primarily product condition defects; and mechanical or physical damage-related losses were those caused by rough handling, inadequate packaging and mechanical injury. In each of these studies, mechanical losses generally comprised at least 65 percent of total losses. Summarized results of these two studies are found in Tables 2 and 3.

Table 2. Produce Losses at Wholesale in Chicago--1966 to 1969

Produce Item	Amount Sampled	Nature of Losses			Total Losses
		Parasitic	Non-Parasitic	Physical	
	(pounds)	(percent)	(percent)	(percent)	(percent)
Delicious Apples	2,536	.1	.5	2.3	2.9
Head Lettuce	2,548	.5	1.6	3.6	5.7
Navel Oranges	2,070	1.5	.3	.2	2.0
Valencia Oranges	2,037	.9	.4	.1	1.4
Peaches	1,090	2.4	.5	9.4	12.3
Red Potatoes	4,915	1.3	.7	2.9	4.9
Long-White Potatoes	1,697	.3	.5	1.7	2.5
Strawberries	845	2.7	2.1	8.7	13.5

Source: See (61).

Table 3. Produce Losses at Wholesale in New York--1966 to 1969

Produce Item	Amount Sampled	Nature of Losses			Total Losses
		Parasitic	Non-Parasitic	Physical	
	(number of items)	(percent)	(percent)	(percent)	(percent)
Delicious Apples	8,575	.5	.1	.3	.9
Navel Oranges	6,423	1.1	.3	.5	1.9
Valencia Oranges	5,884	.9	.1	.3	1.3
Head Lettuce	1,770	1.6	1.1	1.4	4.1
Peaches	6,351	.7	--	1.6	2.3
Strawberries	526	3.8	--	2.1	5.9
Potatoes (Maine)	3,673	.3	--	1.0	1.3

Source: See (62).

Produce becomes increasingly susceptible to deterioration during wholesaling activities due simply to the passage of time. Products ripen and soften, and moisture loss continues, perhaps to the point where shriveling or wilting may appear. Decay-causing organisms present at harvest or introduced later in handling continue to incubate and grow. The effect of high temperatures on each of these processes dramatically increases losses of most produce items; thus, the effectiveness of temperature and humidity management on the part of distribution center personnel directly affects produce loss potentials throughout the remainder of the distribution system.

The effect of inadequate temperature and humidity on losses during wholesaling activities cannot be overemphasized. Many different produce items, each having unique temperature and humidity requirements, are brought together at the wholesale level to be consolidated and stored in close proximity prior to selection and delivery to supermarkets. Items such as cabbage, celery and lettuce require temperatures close to 32^{o} F., with high humidity. By contrast, tomatoes are best stored at 58^{o} F. for a moderate rate of ripening, to be followed by a storage temperature of 32-35^{o} F.

Rough handling is a continuing and pervasive problem with respect to produce losses. A study of apple handling pointed clearly to the adverse effects of handling abuses. The study reported that at the packer-shipper level 99 percent of a sample of apples packed for shipment were either bruise-free (64 percent) or slightly bruised (35 percent). Upon arrival at the distribution center, 97 percent of these apples were still in good condition. However, by the time they were delivered to the retail store, only 57 percent were in good condition. The remaining 43 percent of the sample were either moderately bruised (26 percent) or severely bruised (17 percent). Moreover, the study showed that the same kind of apples shipped directly from the packer to the retail store incurred far less damage, with 97 percent arriving in good condition (41).

Produce losses also take place during delivery from distribution centers to supermarkets. When trucks are fully loaded, it is relatively simple to avoid toppling cartons during the trip to the stores. However, in many instances, trucks make several store deliveries, unloading only a portion of the load at each stop. To avoid the risk of toppled loads between stores, it is often necessary to rearrange the remaining cargo after each stop. Failure to do so was observed to be a principal cause of this type of damage. Incidents of such losses were associated with the number of supermarket deliveries per truckload and the nature of driving conditions, i.e., roughness of street pavement, stop-and-go traffic, and the like.

Industry executives attribute a substantial portion of physical produce damage occurring during wholesaling activities to containers which fall, break, catch on obstacles, and so forth. In large part, this is due to extreme variations in the sizes, shapes and types of shipping containers. This kind of damage to products occurs most frequently when cartons are handled individually in loading, unloading and stacking activities. Physical damage also occurs when containers topple simply because of the difficulty of stacking them in a stable manner due to incompatible sizes, shapes and types. Physical damage is most acute during the summer months, when the highly vulnerable soft fruits such as berries, cherries, peaches, plums, etc. are at their peak volumes of distribution. Thus, the loading, unloading and the stacking of containers on carts and pallets is another critical stage in the distribution process insofar as losses are concerned.

Personnel performing wholesaling functions are typically under time constraints which frequently lead to errors. Moreover, they often are insufficiently trained, and lack the incentive to reduce losses by exercising greater care in dealing with an admittedly difficult situation.

Finally, a problem arises from the inadequate labeling of shipping cartons resulting in errors in store shipments. The consequences are out-of-stock situations on some products and excessive stocks of others. The latter situation generally increases losses due to the additional handling of the product in reshipping; and mis-shipments may overcrowd supermarket storage facilities. Indeed, stores electing to keep the extra shipment may engage in over-displaying of products, leading also to higher losses.

Loss Reduction Potentials

The correct handling of properly filled containers can help to maintain product quality and reduce losses during distribution center activities. Limiting the frequency of handling also can contribute to loss reduction. To this end, pre-packaging of produce and palletization of products offer great potential. An alternative for reducing the frequency of handling is a "bulk bin" distribution system being experimented with for the past several years by a few retail chains. The bulk bin container is constructed of either plywood, fiberglass, steel, wood or corrugated fiberboard. It may be square or octagonal in shape, typically 36 inches high and designed to fit the 48" x 40" pallet base. Such bins may hold up to 1,000 pounds of product (4). The initial intended use of bulk bins was to facilitate the movement of bulk produce from the field to prepack warehouses, thereby achieving a reduction in product handling. In some instances, bulk bins are bypassing warehouses, moving directly from the field to the retail display floor, resulting in even fewer handlings. One analysis of this method revealed that in at least some instances the use of bulk bins, while increasing physical losses by up to 2 percent, also resulted in substantial labor savings associated with less handling. This more than compensated for the added cost of product losses. This is one example of how resource trade-offs can result in improvements in overall system efficiency at the expense of optimizing a given resource--in this case, the loss of food. Although incurring increased losses, the use of bulk bins in the example of apple shipments resulted in overall lower costs for the entire distribution process from the farm to the consumer.

Improvements in packaging materials have been shown to reduce the incidents of losses caused by packaging failure. Dr. Gunilla Jonson, Michigan State University, found that damage to celery was reduced significantly (59 percent) by using a plastic board container to replace the wirebound crates and the corrugated board containers currently in use (19).

In terms of emerging improved technology, several developments appear promising. Some of the new produce distribution centers are increasing the number of temperature and humidity zones for the storage of produce groups, each of which requires different temperature and humidity storage environments. Another development is the renewed interest in hypobaric storage, a process which maintains produce at constant low pressures in addition to providing ideal temperature and humidity requirements. Seventy-eight hypobaric storage units were recently purchased by intermediaries involved with the distribution of fresh produce to Middle Eastern destinations (28).

LOSSES DURING SUPERMARKETING OPERATIONS

Magnitudes of Losses

Retail produce shrinkage data, as cited in the literature, varied from 3.6 percent to 11 percent of retail sales. It should be noted that, in this case, shrinkage refers to the difference between expected and actual sales receipts and thus, includes factors such as theft and price markdowns in addition to losses for human consumption. One study placed the dollar value of shrinkage on a nation-wide basis at $300 million to $500 million annually. On a smaller scale, a single supermarket with produce sales of $5,000 per week and a loss rate of 5 percent would lose $13,000 each year (33).

Interviews with retail produce managers revealed the following additional information with respect to produce shrink losses:

- 3.25 percent overall produce shrinkage was reported in a small West Coast chain.
- 6 percent bulk shrinkage and 4 percent pre-pack shrink loss in a Southeastern chain.
- 5 percent shrinkage loss on "hard fruit," 7-8 percent loss on "soft fruit," and commonly 15-20 percent shrinkage on lettuce in a large Midwestern chain.

Causes of Losses

The 1965 USDA study, "Losses in Agriculture," dealt with retail losses of fruits and vegetables. Summaries of these findings are presented in Appendices V and VI. The study found that one important cause of produce losses resulted from trimming vegetables in order to present attractive, saleable products to consumers. A second cause resulted from discarded, unsaleable produce which had exceeded its shelf life due to substantial decay. It was determined, however, that price discounts caused by product deterioration constituted almost two-thirds of the economic losses associated with fruits and vegetables in retail stores--although these products were not, of course, lost for human consumption (58).

One of the principal causes of produce losses in supermarkets--as at all levels of distribution--is the failure to adequately store products at proper temperature and humidity conditions. The main reason is that frequently supermarkets' refrigerated storage space becomes overburdened. In some cases, space in supermarkets is designed to accommodate a certain level of weekly sales; if, however, sales exceed the designed capacity, crowded storage facilities may result. Moreover, low profit margins which characterize the supermarket industry tend to restrict the availability of capital required for the installation of needed additional produce storage facilities. Thus, produce which should be protected is often stored and displayed at room temperatures. Interviews with supermarket industry personnel suggested that the magnitude of this problem may not be sufficiently appreciated by top management.

Two studies of a limited number of produce items marketed in New York and Chicago concerned the nature and extent of retail losses in apples, oranges, lettuce, peaches, strawberries and potatoes. Results of this study are shown in Tables 4 and 5. Parasitic and physical losses were the major causal factors. Non-parasitic losses were significantly less important. Percentages of total losses ranged from .8 percent for Valencia oranges to 5.8 percent for peaches.

Table 4. Produce Losses at Retail in Chicago--1966 to 1969

Produce Item	Amount Sampled	Nature of Losses			Total Losses
		Parasitic	Non-Parasitic	Physical	
	(pounds)	(percent)	(percent)	(percent)	(percent)
Red Delicious Apples	32,327	.2	.2	2.5	2.9
Head Lettuce	41,809	.7	.4	.6	1.7
Navel Oranges	64,947	1.2	.2	.2	1.6
Valencia Oranges	16,184	.7	.1	--	.8
Peaches	38,687	1.2	.1	--	5.8
Red Potatoes	44,300	.1	.2	--	1.0
California & Southern Strawberries	4,045	1.5	.1	--	5.5

Source: See (61).

Table 5. Produce Losses at Retail in New York--1966 to 1969

Produce Item	Amount Sampled	Nature of Losses			Total Losses
		Parasitic	Non-Parasitic	Physical	
	(number of items)	(percent)	(percent)	(percent)	(percent)
Red Delicious Apples	59,862	.3	.1	.6	1.0
Navel Oranges	119,987	1.5	.1	.3	1.9
Valencia Oranges	76,178	.9	.1	.2	1.2
Head Lettuce	9,492	1.5	.4	2.7	4.6
Peaches	101,220	1.7	--	2.8	4.5
Strawberries	5,418	3.6	--	1.3	4.9

Source: See (62).

A university of California study revealed that 62 percent of the tomatoes which were ultimately unmarketable at the retail level possessed measurable defects at the shipping point immediately following harvest. This study, as well as recommendations for loss reduction procedures expressed by retail produce managers, indicate the need for much more careful grading and inspection at the packing level to ensure that better quality produce enters the marketing channel.

The study also reported that total fruit classified as "unmarketable" increased from 11 percent at the initial shipping point to 17 percent at the retail level. Bruising, the major cause of losses, accounted for 63 percent of all defects at retail (25).

There are instances when government regulations may be a contributing factor with respect to produce losses. For example, some wholesale buyers indicated that regulations prevented them from rejecting shipments, which, although in saleable condition upon delivery at wholesale, would certainly deteriorate rapidly because of inordinately high temperatures which had existed during transit.

L. B. Darrah estimated that average waste and spoilage of produce in retail stores ranged from 5 to 7 percent of total produce sales. The three main loss categories were: spoiled products arriving at stores; products requiring price reductions for sale; and products deteriorating in the retail store which were finally discarded. Causes of these losses included: inadequate refrigeration and humidity; excessive time between harvest and sale to consumers; excessive dehydration; harvest damage; disease; poor packing; and abusive handling by store personnel and consumers. Darrah noted that consumer handling abuse tended to be greater in bulk displays than when produce was pre-packaged (9).

One of the most pervasive causes of store level produce losses is improper handling by produce department employees. Produce managers interviewed in the field suggested that the following personnel-related problems contribute significantly to losses at retail:

- Overstocking. Frequently, the shelf space allocated to given produce items exceeds that justified by normal turnover rates. Under such conditions, losses escalate as product turnover rates decrease.

- Lack of Proper Stock Rotation. Produce personnel often find it easier to add fresh produce on top of existing and older stock currently on display. In one sense, employees in this way achieve attractive displays and expend less effort in restocking; however, the result is increased losses due to greater quantities of unsaleable produce.

- Overtrimming. The removal of outer leaves results in accelerated produce deterioration since the protection offered by these leaves is eliminated. Furthermore, on a per pound basis, trimming results in less produce for sale.

Improved personnel management at the store level is a key to the reduction of many of the losses cited. However, this need is not fully recognized by retail executives responsible for this task. Where companies have initiated positive steps to select employees qualified for produce department tasks, barriers to progress occasionally exist. For example, under some unionized conditions, retail firms have reported that collective bargaining agreements call for seniority provisions as the basis of in-store department assignments. Such procedures can obstruct the effort to select and train persons best suited to the tasks associated with this department. In general, better selection, training and motivation of personnel is needed, although the benefits of this process have not as yet attracted the kind of attention commensurate with needs in most retail organizations. There appears to be a general lack of recognition that a planned training program is necessary for workers in the produce department. Trade associations might play a leading role in communicating these problems and their solutions to their industry membership.

Unseasonal weather also is a cause of losses at the supermarket level. Just as weather impacts on the amount and the condition of produce harvested and supplied to the marketplace so, also, does it impact upon the demand expressed by consumers. Retail chain produce buyers typically accumulate inventories of certain commodities at particular times of the year, especially for holidays. In anticipation of summer holiday picnic shopping, for example, extra stocks of watermelons and sweet corn may be accumulated. Rainy weather, or even forecasts of inclimate weather, may sharply reduce short-term demand. The result is that sizeable quantities of these perishable produce items spoil. Variations in shopping demand are difficult to forecast with precision, and it is likely that imperfect, short-run matching of supply and demand will continue to be a problem in need of attention. However, computerized ordering coupled with the application of UPC scanner sales information hold great promise for reducing these kinds of losses.

Another way by which weather conditions contribute to produce losses is in its effect on the distribution processes. Several distribution functions are typically performed in uncontrolled temperature environments: distribution centers' receiving, shipping docks and staging areas; and supermarkets' receiving docks, backrooms and display cases. Coincidentally, the warmest months are those in which the most fragile produce items, such as soft fruits, are in the distribution channel. Thus, during hot weather produce losses are magnified.

Losses of some produce items in supermarkets are related to item turnover and basic consumer demand. Slower moving items generally experience higher losses for several reasons: on average, they take longer to sell; sales may fluctuate because they are more dependent upon variable factors such as weather; and, in some cases, slower moving items are the most fragile items in terms of bruising, deterioration and other loss-causing damage.

Finally, some retail losses may be attributed to local ordinances. In Chicago, for example, lettuce must be sold by weight, not by the head. This leads to closer trim in order to respond to consumer preferences, contributing, therefore, to comparatively higher losses.

Loss Reduction Potentials

Corrective actions to respond to loss and damage in supermarkets parallel the recommendations for loss reduction in the other aspects of produce distribution. Such suggestions for improvements in transportation and wholesaling, if implemented, would most likely result in improved quality produce received at the retail level. The consequence of this would be enhanced shelf life and reduced losses. And, as it was mentioned earlier, more careful grading after harvest also appears to be a prerequisite for substantial loss reduction in stores.

One method of reducing losses frequently mentioned in field interviews is to increase the pre-packing of produce. Pre-packaging can be accomplished at the packer level, in the distribution center, or in the supermarket. In a Super Market Institute study, retail firms emphasizing pre-packaging in their produce departments were polled concerning the possible advantages they experienced from pre-packaging. Fifty-one percent responded, "less shrink;" 20 percent claimed "fresher produce and longer shelf life;" and 9 percent reported "better quality produce" (45). There are strong regional differences in the industry with respect to retailer use of pre-packaging. The West, South Central, Mountain and Pacific areas reflect a low proportion of stores using pre-packaging, at most 30 percent. However, in the Central, East and South regions, the percentage of supermarkets using pre-packing ranges up to 95 percent. When losses were analyzed on this regional basis, a strong correlation between loss reduction and pre-packaging was <u>not</u> found.

A 1972 study of retail apple marketing included an examination of losses. Recommendations were made for improved methods for handling apples. In many respects, those very recommendations have general applicability to all fresh produce:

- In stores which are closed on Sundays, produce items which require refrigeration should be returned to the cooler Saturday evening.
- Often large volumes of produce are used in the construction of impressively large displays. An equally impressive display can be accomplished by the use of a "built-up" stand to take the place of a mass of underlying produce.
- The display should be checked periodically and out-of-condition product removed at least once a day.
- Dating or semi-weekly coding of pre-packed produce helps to maintain an accurate system of rotation for displayed items.
- The angle of adjustable display racks is often set too steeply, resulting in produce damaged by excessive rolling and perhaps falling to the floor.

The study also formulated several recommendations for practices prior to shipping apples, including: firmness testing; use of scale and decay inhibitors; and proper container marking (26).

Various forms of supermarket employee training programs to reduce improper handling have been implemented by many retail firms. Subject matter covered included preparation of produce, sanitation, produce rotation, and quality control in addition to loss control. However, the contents of company training programs are not for publication, and are unavailable for industry-wide use.

In addition to the critically important "people programs," improvements in equipment and facilities also offer promise for loss reduction. A few retail chains are experimenting with compartmentalized, in-store produce storage zones where predetermined temperature and humidity conditions are maintained in order to accommodate the various temperature and humidity requirements of different kinds of produce. Loss reduction performance data are not available with respect to these systems, although management anticipates the additional costs associated with "zoned storage" facilities will be more than offset by reductions in produce losses and more favorable consumer purchasing response. Improved consumer sales response is anticipated since there is general acknowledgement among industry executives that the physical attractiveness of produce is the single most important factor influencing sales. Thus, one can assume that higher quality, more attractive produce for retail display generally results in reduced losses from markdowns and throw-aways.

SUMMARY AND CONCLUSIONS

Total produce losses occurring within the distribution system are determined in this study by summing losses in the operations of each of the distribution phases previously described--transportation, wholesaling and supermarketing. However, as earlier sections have indicated, secondary data are incomplete and often are limited to specific produce items and situations. Further, there is a lack of consistent measurement used within the various phases of the distribution system. Thus, aggregate losses data are subject to substantial imprecision. Table 6 presents approximations of produce losses in the distribution system. These figures are based upon secondary data as well as limited field study of industry sources.

It is important to note the nature of these loss estimates. First, the ranges of losses are very broad. They reflect substantial variations in practices and performance by firms within the produce distribution system. Moreover, the information bases used to develop the ranges of losses are too limited to assume that "average losses" occur at the midpoint of each range. Thus, representative averages have not been presented and cannot be determined based upon data from Table 6.

Table 6. Estimated Ranges of 1977 Produce Losses in the Distribution System[1]

Distribution Activity	Losses[2]	Value of Losses[3]
	(percent)	(millions of dollars)
Transportation	3.80 - 5.00	268.70 - 379.81
Wholesaling	2.50 - 5.03	176.86 - 381.75
Retailing	2.74 - 6.58	194.01 - 500.33
Systems Losses	9.04 - 16.61	639.57 - 1261.89

[1]Losses cited are estimated values of physical quantities of food lost for human consumption. Costs of recoup, trimming, salvage operations and numerous indirect costs associated with losses and damage are not included.

[2]Percentage losses are based upon dollar values of losses in each phase of distribution as a percentage of the wholesale value of products entering the distribution system. Wholesale values of products entering the system are estimated to have ranged from $7,071.00 million to $7,596.22 million. This range accommodates the given loss rates and supermarket produce sales of $9,506.49 million (7).

[3]Losses in transportation and wholesaling activities are valued at wholesale prices and losses at retail are valued at retail prices. The estimated retail gross margin of product is 31.7 percent (7).

Second, the aggregate dollar losses appear extremely large, perhaps suggesting huge food loss reduction potential. Although it seems possible to achieve substantial loss reductions, it should be remembered that by comparison to these aggregate data, individual incidents resulting in losses are quite small. Whereas the aggregate systems-wide losses are estimated to range from approximately $640 million to $1.3 billion, the majority of individual loss situations would probably be measured only in cents! Thus, it seems unlikely that losses can be significantly reduced by single or simplistic actions.

Fundamental solutions to reduce losses are those which are likely to involve better coordination of each of the component functions of the entire produce distribution system. Improved transportation, centralized packaging, and standardized carton sizes, for example, will require extensive cooperation and coordination on the part of most members of the produce marketing system. Much of the loss reduction gain must result from retail firms through the application of improved business management, particularly with respect to more effectively managing the interface functions between the distribution center and the supermarket. In supermarkets, themselves, more highly trained and motivated produce managers are needed to affect loss reduction improvement, especially with respect to the problem of improper handling and inadequate temperature and humidity. Thus, improvements in management as well as in physical distribution practices are requisite to loss reductions without adding to the total net cost for distributing produce. Industry associations, universities and government agencies can significantly contribute to these objectives.

Some of the methods currently being used to reduce produce losses include: techniques to improve temperature maintenance, palletization and unitized handling, and the utilization of packaging that provides optimum physical protection while allowing for adequate ventilation for highly perishable produce products.

However, the full potential to reduce or prevent produce losses will not be achieved until awareness of produce losses becomes more prevalent throughout business, government and university institutions.

Important information gaps exist. For example, more detailed knowledge is needed in the following areas: the determination of nutrient losses in different segments of the distribution system; the amounts of produce losses experienced during truck transport; identification of barriers to loss reduction and prevention; and the economic implications of these losses. Such additional information would provide a more thorough understanding of produce losses which appears essential for directing efforts toward truly effective solutions.

The final portion of this report presents three separate summaries. The first lists major causal factors for produce losses occurring during distribution. This list identifies and generalizes the causes for losses at a basic level. The letters in parentheses to the right of each factor in the summary provide a coding system. The codes are used along with the specific causes for losses which are listed next.

The second summary identifies specific causes for losses in the contexts of the phases and functions of the distribution system. The major causal factor codes indicate the related underlying causes.

The third summary provides a preliminary list of potential remedies for produce loss reductions. It is not intended to indicate that such remedies are either technologically or economically feasible, but only that there are numerous opportunities which warrant careful consideration and analysis, and indeed, this is the initial requisite step in reducing losses and improving the effectiveness of the food distribution system.

Major Causal Factors for Produce Losses

- Handling (H)
- Temperature and Humidity (T)
- Packaging Materials and Processes (P)
- Slow or Unpredictable Demand (D)
- Government Regulations or Lack Thereof (G)
- Limited Product Life (L)
- Trim and Spoilage (S)
- Moisture Evaporation (M)
- Poor Quality Product Entering Distribution (Q)

Specific Causes for Produce Losses

- During Transportation Operations--Packer to Wholesaler
  - Trailer not precooled prior to loading (T)
  - Refrigeration unit not functioning properly or improperly operated (T)
  - Regulations restrict rejection of products even when shelf life is reduced (G)
  - Product improperly stacked inhibiting proper air circulation (T)
  - Product damaged during loading, in transit, or unloading (H)
  - Product delayed in transit (L)
  - Packaging fails to provide reasonable protection under normal loading, in-transit, and unloading conditions (P)
  - Moisture losses (M)
- During Wholesaling Operations
  - Product damaged in handling (H)
    - On receiving and shipping dock
    - During movement to produce storage area
    - During storage
    - During assembly and loading for shipment to supermarkets

* Inability to meet item-by-item temperature and humidity standards (T-M)
* Poor quality due to lack of grade standards for low volume specialty products (G)
* Failure to redistribute load during deliveries (H-P)
* Trim losses and spoilage (S)
* Multiplicity of secondary container sizes leads to unstable mixed pallet loads (P)
* Poorly labeled packages increase potential for losses (P)
* Packaging fails to provide reasonable protection under normal handling and storage conditions (P)

- During Supermarket Operations
    * Product damaged in handling (H)
        -- Unloading of delivery trucks
        -- Handstacking of in-store carts
        -- Movement to backroom and display case
        -- Pricing and stocking in the display case
    * Inability to meet item-by-item temperature and humidity standards (T-M)
    * Unforeseen demand conditions (D-L)
    * Trim losses and spoilage (S)
    * Damage during consumer purchase activities (H)
    * Slow moving items (D-L)
    * Overstocking of display case (T-S-M)
    * Laws requiring sales by weight lead to closer trim (G-S)

Remedies for Produce Losses

- Improve Handling
    * Consider an increased professional orientation to produce management
    * Upgrade employee training through all aspects of produce distribution
    * Reduce handling steps

- Improve Temperature and Humidity Control
  * Encourage increased use of refrigerated display space
  * Develop improved display stocking policies and procedures
  * Consider greater use of distribution centers with multiple temperature and humidity zones
  * Encourage the use of time and temperature recorders
  * Reduce exposure to uncontrolled temperature and humidity environments
- Improve Packaging
  * Move to performance-rated packaging to accommodate reasonable handling practices and conditions
  * Initiate the development of a program for modular secondary containers
- Improve Governmental Regulations
  * Consider the adoption of grade standards for specialty products
  * Review existing regulations that may be leading to losses of perishables
- Improve Vertical Coordination
  * Upgrade vertical coordination back through agricultural production
  * Improve supermarket ordering procedures
- Improve Raw Product Quality
  * Develop new fruit and vegetable varieties with improved shelf life and handling characteristics
  * Develop new technology for the improvement of handling and shelf life characteristics

Appendix I

Compatibility of Fresh Fruits and Vegetables

Group 1

Apples
Apricots
Berries (except cranberries)
Cherries
Figs (not with apples, danger of odor transfer to figs; also see Group 6a)
Grapes (see Commodities with Special Requirements; also see Group 6a)
Peaches
Pears
Persimmons
Plums
Prunes
Pomegranates
Quinces

* * * * * * * * * * * *

Recommended Transit Conditions:

Temperature: 32^{o} to 34^{o} F. (0^{o} to 1.5^{o} C.).
Relative humidity: 90 to 95 percent.
Atmosphere: Normally used on barries and cherries only--10 to 20 percent CO^2.
Ice: Never in contact with commodity.

* * * * * * * * * * * *

Note: Most members of this group not compatible with Group 6a or 6b because ethylene production by Group 1 can be high, and thus harmful to members of Groups 6a or 6b.

Group 2

Avocados (see Commodities with Special Requirements)
Bananas
Eggplant (also see Group 5)
Grapefruit, Arizona and California; Florida before Jan. 1 (see Commodities with Special Requirements--Citrus Fruits)
Guava
Mangoes
Muskmelons, other than cantaloupes--Casaba, Crenshaw, Honeydews, Persian
Olives, fresh
Papayas
Pineapples (not with avacados, danger of avocados' odor absorption)
Tomatoes, green
Tomatoes, pink (also see Group 4)
Watermelons (also see Groups 4 and 5)

* * * * * * * * * * * *

Recommended Transit Conditions:

Temperature: 55^{o} to 65^{o} F. (13^{o} to 18^{o} C.).
Relative humidity: 85 to 95 percent.
Ice: Never in contact with commodity.

Appendix I

Compatibility of Fresh Fruits and Vegetables (Continued)

Group 3

Cantaloupes
Cranberries
Lemons (adjust temperature to other commodity; see Commodities with Special Requirements)
Lychees (also see Group 4)
Oranges (see Commodities with Special Requirements)
Tangerines (see Commodities with Special Requirements)

* * * * * * * * * * * *

Recommended Transit Conditions:

Temperature: 36^{o} to 41^{o} F. (2.5^{o} to 5.0^{o} C.).
Relative humidity: 90 to 95 percent; cantaloupes about 95 percent.
Ice: In contact only with cantaloupes.

Group 4

Beans, snap
Lychees (also see Group 3)
Okra
Peppers, green (not with beans)
Peppers, red (if with green peppers, temperature adjusted toward top of range)
Squash, summer
Tomatoes, pink (also see Group 2)
Watermelons (also see Groups 2 and 5)

* * * * * * * * * * * *

Recommended Transit Conditions:

Temperature: 40^{o} to 45^{o} F. (4.5^{o} to 7.5^{o} C.).
Relative humidity: About 95 percent.
Ice: Never in contact with commodity.

Group 5

Cucumbers
Eggplant (also see Group 2)
Ginger (not with eggplant, also see Group 7)
Grapefruit, Florida (after Jan. 1) and Texas
Limes (see Commodities with Special Requirements)
Potatoes (late crop)
Pumpkin and Squashes, winter
Watermelon (temperature adjusted for other members of group; also see Groups 2 and 4)

* * * * * * * * * * * *

Recommended Transit Conditions:

Temperature: 40^{o} to 55^{o} F. (4.5^{o} to 13^{o} C.); ginger not below 55^{o} F.
Relative humidity: 85 to 90 percent.
Ice: Never in contact with commodity.

Appendix I

Compatibility of Fresh Fruits and Vegetables (Continued)

Group 6a

This group, except for figs, grapes and mushrooms, is compatible with Group 6b.

Artichokes
Asparagus
Beets, red
Carrots
Endive and escarole
Figs (also see Group 1)
Grapes (see Commodities with Special Requirements, also see Group 1)
Greens
Leek (not with figs or grapes)
Lettuce
Mushrooms
Parsley
Parsnips
Peas
Rhubarb
Salsify
Spinach
Sweet corn
Watercress

* * * * * * * * * * * *

Recommended Transit Conditions:

Temperature: 32^{o} to 34^{o} F. (0^{o} to 1.5^{o} C.).
Relative humidity: 95 to 100 percent.
Ice: Never in contact with asparagus, figs, grapes and mushrooms.

Group 6b

This group, except for figs, grapes, and mushrooms is compatible with Group 6a.

Broccoli
Brussels sprouts
Cabbage
Cauliflower
Celeriac
Celery
Horseradish
Kohlrabi
Onions, green (not with rhubarb, figs, or grapes; probably not with mushrooms or sweet corn)
Radishes
Rutabagas
Turnips

* * * * * * * * * * * *

Recommended Transit Conditions:

Temperature: 32^{o} to 34^{o} F. (0^{o} to 1.5^{o} C.).
Relative humidity: 95 to 100 percent.
Ice: Contact acceptable for all.

Appendix I

Compatibility of Fresh Fruits and Vegetables (Continued)

Group 7

Ginger (also see Group 5)
Potatoes, early crop (temperatures adjusted for others)
Sweet potatoes

* * * * * * * * * * * *

Recommended Transit Conditions:

Temperature: 55^{o} to 65^{o} F. (13^{o} to 18^{o} C.).
Relative humidity: 85 to 100 percent.
Ice: Never in contact with commodity.

Group 8

Garlic
Onions, dry

* * * * * * * * * * * *

Recommended Transit Conditions:

Temperature: 32^{o} to 34^{o} F. (0^{o} to 1.5^{o} C.).
Relative humidity: 65 to 75 percent.
Ice: Never in contact with commodity.

Commodities with Special Requirements

Avocados
Ripening would be rapid at 55^{o} to 65^{o} F. (13^{o} to 18^{o} C.); chilling injury may occur below 50^{o} F. (10^{o} C.).

Citrus Fruits
Biphenyl, which is used as a fungicide on citrus fruits, may impart off-odors to other commodities.

Lemons--For holding one month or less, 32^{o} to 55^{o} F. (10^{o} to 13^{o} C.) is necessary.

Limes--Do not hold below 45^{o} F. (7.5^{o} C) longer than about 2 weeks.

Oranges and Tangerines--Compatibility depends on source. Florida-grown or Texas-grown oranges are shipped at 32^{o} to 40^{o} F. (0^{o} to 4.5^{o} C.), but California-grown and Arizona-grown ones are shipped at 40^{o} to 44^{o} F. (4.5^{o} to 7^{o} C.).

Grapes
Compatible with other crops only if the grapes are not fumigated with sulfer dioxide (SO^{2}) in vehicle and if no chemicals that release SO^{2} are included in packages.

Source: See (43).

Appendix II

Fruits: Estimated Average Annual Losses During Transit and Unloading

Commodity	Unit of Measure	Loss in Quantity[1,2]		Loss in Quality	Loss in Value[2]
		(Percent)	(1,000 Units)	(Percent)	($1,000)
Apples	Bushel	2[3]	2,110	2.0	7,801
Apricots	Ton	1[4]	2	---	232
Avocados	"	2[4]	1	---	181
Cherries	"	2[4]	2	---	475
Grapefruit	"	1[3]	16	.5	722
Grapes	"	1[3]	29	8.0	13,626
Lemons	"	1[3]	6	.1	436
Limes	Box	5[4]	1	---	64
Oranges	Ton	1[3]	53	3.0	11,841
Peaches	Bushel	3[3]	1,842	5.0	9,768
Pears	"	1[3]	277	.4	707
Plums	Ton	1[3]	837	1.0	285
Pomegranates	"	1[4]	(5)	---	2
Prunes	"	1[3]	4	2.0	1,328
Strawberries	Pound	5[2]	11,649	5.0	5,017
Tangerines	Ton	2[3]	4	3.0	468
Total					52,953

Source: See (58).

[1]Percentage data include that part of the packaged commodity which is inedible because of disease or destruction.

[2]Basic data for quantity and value represent the quantity marketed and value of the quantity marketed, respectively.

[3]Judgment estimates made by specialists.

[4]Losses are based on information from inspection certificated from Pittsburg Produce Inspection Service from 1957 to 1961.

[5]Less than 1,000 tons.

Appendix III

Vegetables: Estimated Average Annual Losses During Transit and Unloading

Commodity	Unit of Measure	Loss in Quantity: Percentage[1]	Loss in Quantity: Amount[2]	Loss in Quality	Loss in Value[2]
		(Percent)	(1,000 Units)	(Percent)	($1,000)
Artichokes	Hwt.	1[3]	3	---	31
Asparagus	Ton	3[4]	35	---	472
Beans:					
Lima	Bushel	13[4]	54	---	445
Snap	"	3[4]	385	---	3,328
Beets	"	1[4]	6	---	16
Broccoli	Hwt.	0.5[3]	10	0.4	149
Brussells sprouts	Ton	2[4]	12	---	102
Cabbage	Hwt.	1[3]	195	3.0	1,622
Carrots	"	1[3]	151	.1	503
Cantaloups	"	1[3]	118	5.0	3,115
Cauliflower	"	3[3]	76	4.0	1,127
Celery	"	2[3]	294	1.0	1,820
Corn, sweet	"	---	---	.2[2]	89
Cucumbers	Bushel	2[4]	79	---	400
Eggplant	"	5[4]	23	---	120
Escarole	Hwt.	17[3]	122	4.0	701
Lettuce	"	3[3]	976	7.0	13,139
Melons, honeydew	"	3[3]	44	4.0	497
Onions:					
Dry	"	4[3]	916	1.0	3,060
Green	"	2[3]	3	2.0	37
Peas (in shell)	"	1[3]	4	---	31
Peppers, sweet	"	3[3]	87	1.0	987
Potatoes	"	1[3]	2,010	1.0	8,160
Spinach	"	1[3]	18	2.0	318
Sweetpotatoes	Bushel	19[4]	2,055	---	8,591
Tomatoes	Hwt.	4[3]	767	6.0	13,681
Watermelons	"	8[3]	2,299	8.0	6,499
Total					68,840

Source: See (58).

[1]Percentage data include that part of the packaged commodity which is inedible because of disease or destruction.

[2]Basic data for quantity and value represent the quantity marketed and value of quantity marketed, respectively.

[3]Losses are based on information from inspection certificates from Pittsburg Produce Inspection Service from 1957 to 1961.

[4]Judgment estimates made by specialists.

Appendix IV

Railroad Freight Loss and Damage

Calendar Years	Total (1001)	Shortage Pkged. Ship.		Shortage Bulk Ship.		Not Otherwise Accounted For		Defective Equipment		Temperature Failure		Delay		Theft		Concealed Damage		Train Accident		Fire, Marine and Catastrophe		Error of Employee	
	$	$	%	$	%	$	%	$	%	$	%	$	%	$	%	$	%	$	%	$	%	$	%
Potatoes																							
1966	1,711,254	85,548	5.0	6,502	.4	891,811	52.1	32,653	1.9	379,020	22.1	185,479	10.8	4,728	.3	1,108	.1	79,907	4.7	27,428	1.6	17,100	1.0
1967	1,650,120	64,593	3.9	16,277	1.0	837,263	50.7	15,146	.9	395,914	24.0	198,902	12.1	4,608	.3	6,652	.4	58,059	3.5	33,601	2.0	20,350	1.2
1968	1,571,389	102,867	6.5	16,253	1.0	738,281	47.0	30,775	2.0	401,013	25.5	172,707	11.0	5,672	.4	14,229	.9	18,472	1.2	43,320	2.8	27,640	1.7
1969	1,597,513	39,060	2.5	15,493	1.0	713,576	44.9	11,660	.7	464,275	29.2	171,130	10.8	7,913	.5	659	.1	83,0[illegible]	5.2	52,357	3.3	20,[illegible]	1.3
1970	1,752,822	55,336	3.2	26,012	1.5	734,999	41.9	20,974	1.2	502,266	28.7	281,811	16.1	12,998	.7	112	-	54,924	3.1	45,135	2.6	18,205	1.0
1971	1,852,409	45,442	2.4	10,540	.5	676,921	36.0	18,018	1.0	653,577	36.3	310,617	16.5	16,204	.9	79	-	57,534	3.0	52,913	2.8	10,744	.6
1972	1,930,196	52,708	2.7	3,529	.2	475,696	24.6	22,752	1.2	829,411	43.0	409,679	21.2	19,435	1.0	1,992	.1	64,062	3.3	34,252	1.8	16,600	.9
1973	1,711,077	37,580	2.2	4,925	.3	360,820	21.0	27,093	1.6	790,132	45.2	360,534	21.1	25,178	1.5	-	-	48,139	2.8	41,617	2.4	15,008	.9
1974	2,356,024	45,753	1.2	4,733	.2	402,160	17.1	21,537	.9	1,236,002	52.4	442,509	18.8	58,080	2.5	-	-	66,790	3.0	52,952	2.2	25,203	1.1
1975	2,516,959	42,611	1.7	6,504	.2	342,387	13.6	42,227	1.7	1,332,847	53.0	578,814	23.0	50,055	2.0	177	-	63,617	3.0	29,638	1.2	27,332	1.1
Fresh Fruits																							
1966	3,411,781	147,075	4.3	21,240	.6	1,661,953	48.7	87,227	2.6	574,200	16.8	680,691	20.0	7,784	.2	3,056	.1	146,250	4.3	48,233	1.4	33,976	1.0
1967	3,293,203	116,157	3.5	38,044	1.2	1,520,705	46.2	71,645	2.2	719,819	21.8	580,554	17.6	10,270	.3	21,751	.7	113,511	3.4	59,449	1.9	41,255	1.2
1968	3,570,973	99,296	2.8	34,813	1.0	1,515,747	42.4	77,152	2.2	1,031,055	28.9	484,307	13.5	28,726	.8	2,777	.1	177,250	5.0	87,458	2.4	31,494	.9
1969	4,009,332	98,679	2.5	37,024	.9	1,662,726	41.5	93,006	2.3	1,195,910	29.8	614,467	15.3	36,961	.9	1,658	-	184,174	4.6	70,124	1.7	14,[illegible]	.3
1970	4,555,185	125,747	2.8	28,014	.6	1,575,413	34.6	23,441	.5	1,591,609	34.9	887,185	19.5	26,124	.6	313	-	215,804	4.7	69,029	1.5	12,419	.3
1971	5,173,719	115,607	2.3	25,737	.5	1,246,738	24.1	52,588	1.0	2,162,497	41.8	1,079,341	20.9	77,292	1.5	764	-	284,405	5.5	110,281	2.1	15,589	.3
1972	6,946,179	109,451	1.6	18,959	.3	1,333,544	19.9	89,276	1.3	3,217,268	46.3	1,398,127	20.1	115,477	1.7	545	-	531,945	7.7	53,350	.8	23,338	.3
1973	6,793,727	95,853	1.4	15,170	.2	1,514,722	22.3	70,491	1.0	3,302,464	45.6	1,389,922	20.5	163,787	2.4	-	-	182,617	2.7	27,467	.4	31,234	.5
1974	6,606,891	55,739	.8	22,683	.4	1,672,974	25.4	74,539	1.1	2,903,951	44.0	1,319,148	19.9	240,085	3.6	-	-	267,112	4.0	6,059	.1	47,391	.7
1975	6,591,935	64,540	1.0	18,727	.3	1,391,475	21.1	69,997	1.1	3,183,614	48.3	1,386,671	21.1	168,054	2.5	627	-	252,712	3.8	46,821	.7	8,747	.1
Fresh Vegetables																							
1966	5,650,439	119,095	2.1	29,759	.5	3,035,160	53.7	132,416	2.3	896,582	15.9	1,153,406	20.5	6,958	.1	7,478	.1	199,028	3.5	33,830	.6	35,777	.7
1967	6,612,047	172,759	3.1	105,906	1.9	2,613,874	46.6	154,731	2.8	1,043,662	18.6	1,096,348	19.5	16,584	.3	63,186	1.1	260,569	4.6	38,028	.7	44,230	.8
1968	5,772,455	100,358	1.7	68,504	1.2	2,550,022	44.2	85,300	1.5	1,449,126	25.2	1,225,325	21.2	16,366	.3	7,404	.1	180,410	3.1	29,321	.5	60,450	1.0
1969	5,872,694	93,056	1.6	58,425	1.0	2,136,537	36.5	61,602	1.1	1,767,516	30.4	1,368,455	23.3	44,012	.8	1,152	-	239,146	4.1	27,539	.5	41,184	.7
1970	7,734,414	114,206	1.5	74,592	1.0	2,381,475	30.7	58,954	.8	2,706,453	35.0	1,921,918	25.6	33,962	.4	1,162	-	252,221	3.3	65,669	.9	60,339	.8
1971	7,952,145	120,461	1.5	50,138	.6	1,788,450	22.6	66,962	.8	3,253,110	40.9	2,372,716	29.9	51,093	.6	1,764	-	194,728	2.5	25,485	.3	27,237	.3
1972	11,565,976	121,978	1.0	44,145	.4	2,079,592	17.8	79,759	.8	4,889,435	41.9	3,853,340	33.0	110,554	.9	1,146	-	425,754	3.7	22,457	.2	37,222	.3
1973	12,485,114	95,857	.8	32,719	.2	2,179,692	17.5	107,836	.9	5,469,563	43.7	4,135,922	33.1	114,456	.9	607	-	318,265	2.5	1,359	-	42,453	.4
1974	14,026,194	75,388	.5	40,615	.3	2,481,608	17.7	93,686	.7	5,015,125	35.8	5,358,368	38.2	144,403	1.0	4,999	-	723,080	5.1	36,235	.3	52,667	.4
1975	15,207,076	93,127	.6	30,834	.2	2,751,080	18.2	108,979	.7	6,240,249	41.0	5,420,821	35.6	132,360	.9	3,111	-	335,635	2.2	16,503	.1	74,377	.5

Source: See (1).

Appendix V

Fruits: Estimated Average Annual Losses During Marketing in Retail Stores

Commodity	Unit of Measure	Loss in Quantity[3]		Loss in Value[2]
		(Percent)	(1,000 Units)	($1,000)
Apples	Bushel	3	3,101	5,617
Cantaloups	Hwt.	4	471	2,077
Cherries	Ton	2	4	877
Cranberries	Barrel	1	11	115
Grapefruit	Ton	1	15	474
Grapes	"	7	186	9,644
Lemons	"	7	40	2,719
Melons, honeydew	Hwt.	1	14	65
Oranges	Ton	.4	21	1,137
Peaches	Bushel	6	3,573	6,740
Pears	"	2	548	960
Plums, fresh	Ton	2	2	279
Prunes, fresh	"	2	9	859
Pomegranates	"	.1	3	213
Strawberries	Pound	10	21,900	4,465
Tangerines	Ton	5	9	445
Watermelons	Hwt.	3	793	1,024
Total				37,710

Source: See (58).

[1]Based on marketing studies in six retail stores covering all four seasons.

[2]Basic data for quantity and value represent the quantity marketed and value of quantity marketed, respectively, less the quantity and value of the losses incurred during transit and unloading.

Appendix VI

Vegetables: Estimated Average Annual Losses During Marketing in Retail Stores

Commodity	Unit of Measure	Loss in Quantity[2]		Loss in Value[2]
		(Percent)	(1,000 Units)	($1,000)
Asparagus	Hwt.	1	34	898
Beans:				
Snap	"	2	96	832
Lima	"	1	4	34
Beets	"	6	36	97
Broccoli	"	9	186	1,480
Brussels sprouts	"	1	6	51
Cabbage	"	15	2,896	365
Carrots	"	2	299	905
Cauliflower	"	4	99	599
Celery	"	2	287	1,037
Cucumber	"	5	197	1,001
Eggplant	"	21	88	404
Escarole	"	11	55	190
Lettuce	"	7	2,279	8,277
Onions, dry	"	2	440	1,163
Peas (in shell)	"	10	38	311
Peppers	"	13	363	3,048
Potatoes	"	.2	398	799
Scallions	"	10	13	88
Spinach	"	3	55	308
Sweet potatoes	"	3	324	1,356
Tomatoes	"	6	1,105	7,388
Total				30,131

Source: See (58).

[1]Based on marketing studies in six retail stores covering all four seasons.

[2]Basic data for quantity and value represent the quantity marketed and value of quantity marketing, respectively, less the quantity and value of the losses incurred during transit and unloading.

SELECTED BIBLIOGRAPHY

1. Association of American Railroads. Freight Loss and Damage, Carloadings and Revenue--U.S. Class 1 Carriers. A Series 1966 to 1974, Chicago.

2. Bartz, Don. "Produce Records Must Show Shrinkage, Inventory Carryover." Supermarketing, December, 1974.

3. Bouma, John. "Produce Handling Through Warehouse and Store Backroom." Super Market Institute. Convention Workshop, May 3, 1976.

4. Chain Store Age/Supermarkets. "Behind Safeway's Bulk Bin Test." September, 1977.

5. Chain Store Age/Supermarkets. "Produce Packaging--In-Field Packaging Changing on Industry." August, 1970.

6. Chain Store Age/Supermarkets. "1976 Produce Study." March, 1976.

7. Chain Store Age/Supermarkets. "1977 Department Performance." July, 1978.

8. Coop, Forest A. "A Close Look at Produce Warehousing." Packer's 1st Annual Review & Outlook, Focus 76-77, 1976.

9. Darrah, L. B. Food Marketing. The Ronald Press Company, New York, 1967.

10. Ezell, Boyce D. and Wilcox, Marguerite S. "Loss of Carotene in Fresh Vegetables as Related to Wilting and Temperature." Agricultural and Food Chemistry, April, 1962.

11. Ezell, Boyce D. and Wilcox, Marguerite S. "Loss of Vitamin C in Fresh Vegetables as Related to Wilting and Temperature." Agricultural and Food Chemistry, July, 1959.

12. Gooding, D. I. and Sherman, R. W. Comparative Efficiency of Retailing Produce by Different Packaging Procedures. Agricultural Economics Report #341, Ohio State University, Wooster, Ohio, August, 1963.

13. Hruschka, Howard W. "Shelf Life." 1974 Annual Yearbook United Fresh Fruit and Vegetable Association, Washington, D.C., 1974.

14. International Conference on Handling Perishable Agricultural Commodities. Proceedings of 25th Annual Conference, West LaFayette, Indiana, 1973.

15. International Conference on Handling Perishable Agricultural Commodities. Proceedings of 26th Annual Conference, East Lansing, Michigan, 1974.

16. International Conference on Handling Perishable Agricultural Commodities. Proceedings of 27th Annual Conference, East Lansing, Michigan, 1975.

17. International Conference on Handling Perishable Agricultural Commodities. Proceedings of 28th Annual Conference, East Lansing, Michigan, 1976.

18. Interstate Commerce Commission, Bureau of Accounts. Freight Commodity Statistics of Class I Motor Carriers of Property Operating in Inter-City Service--Common and Contract. U.S. Government Printing Office.

19. Johson, Gunilla. "Plastic Container Board Containers for Fresh Vegetables." School of Packaging, Michigan State University, East Lansing, Michigan, 1974.

20. Kasmire, Robert F. "Proper Ventilation Needed in More Produce Containers." Packer's 1st Annual Review and Outlook, Focus 76-77. 1976.

21. Kretchman, Dale W. "Care and Handling Fresh Fruits and Vegetables in Retail Markets." Department of Horticulture, Ohio State University, Wooster, Ohio, January, 1973.

22. Layton, Steve. "Source Wrapping Offers Profit." Packer's Produce Availability and Merchandising Guide, 1976.

23. Lerner, Richard E. "Freight Loss and Damage Claim Arbitration." 1974 Annual Yearbook United Fresh Fruit and Vegetable Association, Washington, D.C., 1974.

24. LeSeuir, Harold. "Technology Shows Praise for Producers." Packer's 1st Annual Review and Outlook, Focus 76-77, 1976.

25. MacLeod, Richard F.; Kader, Adel A.; and Morris, Leonard L. "Damage to Fresh Tomatoes Can Be Reduced." California Agriculture, University of California, December, 1976.

26. Mattus, G. E. and Kenyon, D. E. "Retail Apple Marketing." Talk delivered at the Regional Trade Show and Horticultural Meeting, Baltimore, Maryland, February 6, 1975.

27. Mitchell, F. G. and Kasmire, R. F. "Temperature Management by Intermediate Handlers." Perishables Handling, March, 1973.

28. Molotsky, Irvin. "Grumman, Diversifying, Markets Food Preserver." New York Times, June 13, 1978.

29. Ostroff, Jim. "Perishables Menaced by Worsening Shipping Problems." Supermarket News, August 7, 1978.

30. Packer, The. "Curing Essential to Stored Onions." October 30, 1976.

31. Packer, The. "Film-Tray Pear Packs Shown to Cool Faster." October 16, 1976.

32. Packer, The. "Produce Regaining Retail Magnetism." February 5, 1977.

33. Packer, The. "Reducing Shrink--Part 1." May 10, 1975.

34. Packer, The. "Reducing Shrink--Part 2." May 17, 1975.

35. Packer, The. "Study Seeks Extension of Citrus Storage Life." November 20, 1976.

36. Packer's Produce Availability and Merchandising Guide. "Store-Level Packaging Cuts Shrink." 1976.

37. Packer's 1st Annual Review and Outlook, Focus 76-77. "Bananas Imports to Rise 10%." 1976.

38. Packer's 1st Annual Review and Outlook, Focus 76-77. "Meeting the Global Food Crisis." 1976.

39. Packer's 1st Annual Review and Outlook, Focus 76-77. "Palletized Loads Winning the West." 1976.

40. Packer's 1st Annual Review and Outlook, Focus 76-77. "Produce Handling--Today and Tomorrow." 1976.

41. Perkins, Frederick A. "Handling Apples from Storage to Customer." Horticultural News, March, 1961.

42. Proceedings of the XIII International Congress of Refrigeration. Washington, D.C., 1973.

43. Produce Marketing Association. 1977 Produce Marketing Almanac. Newark, Delaware, 1977.

44. Railroad Systems and Management Association. Railroad Freight Loss and Damage Prevention Meeting. 1969.

45. Super Market Institute, Inc. Produce Practices and Problems. Special Research Report #3, Chicago, 1973.

46. Supermarketing. "29th Annual Consumer Expenditure Study." September, 1976.

47. U.S. Department of Agriculture, Agricultural Marketing Service. Bruising Injury of Tomatoes, Marketing Research Report No. 513, Washington, D.C., Government Printing Office, 1962.

48. U.S. Department of Agriculture, Agricultural Marketing Service. Field Trimming of Lettuce, by J. M. Horvey, J. K. Stewart, E. A. Atrops, M. J. Ceponis, and P. G. Chapogas. Marketing Research Report No. 497, Washington, D.C., Government Printing Office, 1961.

49. U.S. Department of Agriculture, Agricultural Research Service. Air Transport of California Strawberries: Factors Affecting Market Quality in Summer Shipment--1965, by John M. Horvey, H. Melvin Covey, C. Max Harris, and Frank M. Porter. Marketing Research Report No. 751, Washington, D.C., Government Printing Office, 1966.

50. U.S. Department of Agriculture, Agricultural Research Service. Cabbage, Celery, Lettuce, and Tomatoes--Laboratory Tests and Storage Methods, by C. S. Parsons, L. P. McCollach, and R. C. Wright. Marketing Research Report No. 402, Washington, D.C., Government Printing Office, 1960.

51. U.S. Department of Agriculture, Agricultural Research Service. Current Practices and Trends in Marketing Western Iceberg Lettuce in Relation to Other Produce, by Roger E. Rij, Russell H. Hinds, Jr., R. Tom Hinsch, and C. Max Harris. Marketing Research Report No. 1052, Washington, D.C., Government Printing Office, 1976.

52. U.S. Department of Agriculture, Agricultural Research Service. Effects of Storage Temperature and Humidity on Loss of Weight by Fruit, by Arthur W. Wells. Marketing Research Report No. 539, Washington, D.C., Government Printing Office, 1962.

53. U.S. Department of Agriculture, Agricultural Research Service. Evaluation of Selected Consumer Packages and Shipping Containers for Peaches, by John L. Gimm. Marketing Research Report No. 533, Washington, D.C., Government Printing Office, 1965.

54. U.S. Department of Agriculture, Agricultural Research Service. Evaluation of Selected Shipping Containers for Eastern Grown Peaches, by Philip W. Hale and Earl D. Mallison. Marketing Research Report No. 737, Washington, D.C., Government Printing Office, 1966.

55. U.S. Department of Agriculture, Agricultural Research Service. Evaluation of Shipping Trays and Pads for Pears and Apples, by James B. Fountain. Marketing Research Report No. 530, Washington, D.C., Government Printing Office, 1962.

56. U.S. Department of Agriculture, Agricultural Research Service. Factors Affecting the Quality of Grapefruit Exported from Florida, by John J. Smoot and Randall H. Cubbedge. Marketing Research Report No. 739, Washington, D.C., Government Printing Office, 1966.

57. U.S. Department of Agriculture, Agricultural Research Service. Gamma Radiation of Fruits to Extend Market Life, by William J. Bramlage and H. Melvin Covey. Marketing Research Report No. 717, Washington, D.C., Government Printing Office, 1965.

58. U.S. Department of Agriculture, Agricultural Research Service. Losses in Agriculture. Agricultural Handbook No. 291, Washington, D.C., Government Printing Office, 1965.

59. U.S. Department of Agriculture, Agricultural Research Service. Market Quality of Asparagus--Effects of Maturity at Harvest and of High Carbon Dioxide Atmospheres During Simulated Transit, by W. J. Lipton. Marketing Research Report No. 817, Washington, D.C., Government Printing Office, 1968.

60. U.S. Department of Agriculture, Agricultural Research Service. Market Quality of Film-Wrapped or Naked-Packed Head Lettuce, by Joseph K. Stewart, M. J. Ceponis, and C. M. Harris. Agricultural Research Service Report No. 51-11, Washington, D.C., Government Printing Office, 1967.

61. U.S. Department of Agriculture, Agricultural Research Service. Marketing Losses of Selected Fruits and Vegetables at Wholesale, Retail and Consumer Levels in the Chicago Area, by W. R. Wright and B. A. Billeter. Marketing Research Report No. 1017, Washington, D.C., Government Printing Office, 1975.

62. U.S. Department of Agriculture, Agricultural Research Service. The Nature and Extent of Retail and Consumer Losses in Apples, Oranges, Lettuce, Peaches, Strawberries, and Potatoes Marketed in Greater New York, by M. J. Ceponis and J. E. Butterfield. Marketing Research Report No. 996, Washington, D.C., Government Printing Office, 1973.

63. U.S. Department of Agriculture, Agricultural Research Service. Packaging Produce at the Central Warehouse, by Paul F. Shaffer. Marketing Research Report No. 721, Washington, D.C., Government Printing Office, 1965.

64. U.S. Department of Agriculture, Agricultural Research Service. Polyethylene Liners in Tray Packs Prevent Excessive Moisture Loss and Shriveling of Golden Delicious Apples: An Exhibit. Washington, D.C., 1976.

65. U.S. Department of Agriculture, Agricultural Research Service. Postharvest Weight Loss and Shrivel in Five Fruits and Five Vegetables, by Howard W. Houschka. Marketing Research Report No. 1059, Washington, D.C., Government Printing Office, 1977.

66. U.S. Department of Agriculture, Agricultural Research Service. Pre-packaging Lettuce at Shipping Point, by Peter G. Chapogas and Donald R. Stokes. Marketing Research Report No. 670, Washington, D.C., Government Printing Office, 1967.

67. U.S. Department of Agriculture, Agricultural Research Service, Marketing and Nutrition Research. Market Quality Research Provides New Ways of Protecting Food: An Exhibit. Washington, D.C., 1975.

68. U.S. Department of Agriculture. 1978 Handbook of Agricultural Charts. Agricultural Handbook No. 551, Washington, D.C., Government Printing Office, November, 1978.

69. Walzer, Ed. "'Real' Growth Returns as Sales Hit $143.25 Billion." Progressive Grocer, April, 1976.