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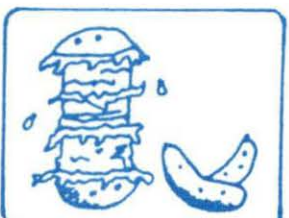
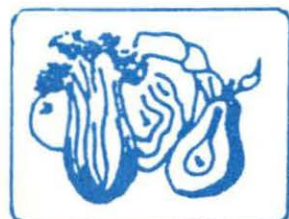
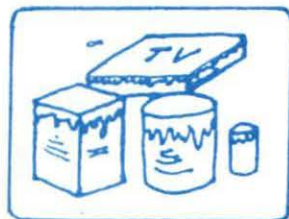
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LOSSES IN U.S. FOOD DISTRIBUTION SYSTEM



FOOD LOSSES Overview and Summary

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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.

This particular report contains: objectives and procedures of the research; discussions of the general magnitudes and causes of food losses; summaries of food losses in each of the seven food product categories; economic issues relating to food losses; and a discussion of the requisites for food loss reduction. The following companion reports also derived from the NSF-RANN study complement this report:

- Fresh Beef Losses in the U.S. Food Distribution System
- Produce 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

LOSSES IN THE U.S. FOOD DISTRIBUTION SYSTEM

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INTRODUCTION

This report presents the general findings of a study conducted for the National Science Foundation -- Research Applied to National Needs to establish estimates of the general magnitudes, causes and location of "food losses" occurring in the U.S. food distribution system. It contains an overview of the objectives and procedures used, as well as summarized findings from the study. Due to the large size of the study and the broad spectrum of food marketing information analyzed, only highlights of the results for each food product category (fresh beef, produce, dairy products, dry groceries, frozen foods, bakery goods, and delicatessen foods) and their implications are provided in this report. Readers interested in detailed information on losses, including selected bibliographies in each of the food product categories, are advised to refer to the appropriate companion report as listed in the preface.

In addition to determinations of the causes and magnitudes of food losses, the research identified several economic principles that must be considered in any discussion of "food loss" prevention or reduction. Finally, a number of requisite needs are identified which must be met before significant reductions in food losses can be attained on a systems-wide basis.

THE STUDY

"Food losses" is a term subject to many interpretations. The purposes and nature of this study dictated the use of a number of different "food losses" terms and concepts: food losses by weight, economic value of physical food losses, total economic costs associated with food losses, shrinkage, and food losses resulting in reductions in either the quantity or quality of food available for human consumption. Although different "food loss" concepts were used,

the study tended toward a single focus: an effort to develop estimates or proxies for the quantities of food lost for human consumption.

In order to accomplish this task within the framework of available resources, it initially was necessary to consider "food losses" in the broader contexts indicated above. Insofar as possible, this information has been honed and transformed, or allowances have been made, to arrive at estimates of the quantities of food lost for human consumption. In this case, losses of food available for human consumption refers to those food products commonly distributed through the contemporary U.S. marketing and distribution systems. Thus, food products which are customarily and purposely discarded were not included as losses even though potentially edible and nutritious. Examples of these kinds of losses include: blood and other animal products not normally consumed in our society, and certain parts of fruits and vegetables that are routinely trimmed and thrown away.

The study covered distribution activities ranging from the packer's, processor's, or manufacturer's shipping dock through transportation, wholesaling, and supermarket retailing operations. Clearly, these operations vary sharply from one another, depending upon the product in question. For example, lettuce may be packed for shipping while still in the field, immediately after harvest. Thus, losses of lettuce are calculated from the time it leaves the field until consumers purchase it in supermarkets. On the other hand, frozen vegetable losses were figured from the time the product leaves the freezing plant or manufacturer's storage facility until consumers purchase it in supermarkets. In all cases, the distribution systems covered in the study were those ending with the supermarket. In most cases, 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 food products were included for study.

In total, seven food product categories have been analyzed. These categories are fresh beef, produce, dairy products, dry grocery, frozen foods, bakery goods, and foods sold through delicatessen departments. Foods within these seven 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 of supermarket food sales, 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.

It was indicated previously that this study is intended to provide basic background information on food losses during distribution. The foregoing concepts of food losses, types of distribution activities, and broad categories of food products were chosen for study to meet the overall objective. Additionally, however, there were a number of more specific objectives, several of which were common to all seven food product categories:

- To identify the general magnitudes and locations of major food losses during distribution activities based upon a thorough inventory of available information.
- To determine the current approaches being used to control food losses and to assess the strengths and weaknesses of these approaches.
- To identify areas of food losses research which may need greater emphasis in order to reduce losses.

Research procedures employed to meet the objectives involved a four-step process:

- (1) An initial, broad based survey of available published information was conducted. Sources of information included: (a) university, U.S. 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.
- (2) The use of a reactor panel composed of representatives from industry, trade association, and government organizations. Panel members commented on preliminary findings and aided in the assembly of source materials beyond those used in the initial reports.
- (3) The reconstruction of selected published data to help develop the required breadth of information.
- (4) A limited number of in-depth interviews with selected industry authorities to provide additional information and to ascertain the reasonableness of findings.

MAGNITUDES OF FOOD LOSSES

Table 1 provides aggregate food loss information covering all seven food product categories studied. A number of points of clarification regarding this information and its appropriate interpretation may be useful. Although the percentage loss figures were collected in 1977 and 1978, they apply to a much broader time period and are believed to be representative of loss rates occurring today.

The percentage losses are based upon dollar values of losses in each stage of distribution as a percentage of the wholesale value of products entering the distribution system. The value of losses during transportation and wholesaling

Table 1. Estimates of Food Losses During Distribution

Food Product Group	Losses	Product Group's Proportion of Super-Market Food Sales
	(percent)	(percent)
Fresh Beef	4.8	13.4
Produce	9.04 - 16.61	9.8
Dairy Products	.63 - 3.50	15.2
Dry Grocery	.382	36.2
Frozen Foods	.98 - 2.85	8.1
Bakery Goods	1.05 - 12.48	4.7
Deli Foods	4.91 - 7.40	5.2
Totals:	1.77 - 3.60 ^{1/}	92.6

^{1/}These figures are based upon a range of 1977 dollar losses--\$1,590 to \$3.234 billion -- as a percentage of 1977 total supermarket food sales.

activities are based upon wholesale prices, whereas, losses at retail are based upon retail prices. In all cases, the estimates apply only to food lost for human consumption. Costs of recoup, salvage operations, and numerous indirect costs associated with losses, even though they are assumed to be substantial, are not included.

For those who are familiar with supermarket retailing statistics, the product group proportions of supermarket food sales may appear unusually large. It should be noted that these are estimated percentages of supermarket food sales

and not total supermarket sales. This distinction arises because supermarkets increasingly sell large quantities of non-food items, although this trend is not uniform throughout the industry. In arriving at these figures, background data has been taken from the trade publication, Chain Store Age Supermarkets, "1978 Sales Manual," July 1978. Other sources for this type of aggregate data may lead to slightly different department sales figures, and thus, to slightly different aggregate loss figures.

The reader should be cautioned that the figures presented may imply a level of precision somewhat beyond what can be justified by the information base. In general, digits to the right of the decimal point have been retained for reasons of consistency rather than to indicate a level of precision. It is also important to realize several significant limitations of the estimates. In some cases, the ranges of losses are very broad. These ranges reflect substantial variation in actual practices and performance being achieved by firms operating in the food distribution systems. Additionally, the informational bases used to develop the ranges are too limited to assume average losses at the center of each range. Thus, representative averages cannot be determined from the ranges presented in Table 1. In the case of dry grocery and fresh beef losses, point estimates could be developed due to the availability of more broadly based information.

With regard to the specific findings, several points stand out. Overall, while the aggregate dollar values of losses during distribution are very large, about \$1.6 to \$3.2 billion, on a percentage basis they tend to be relatively small--ranging from about 1.8 to 3.6 percent of all food moving through the supermarket distribution channels. These percentages, as well as the dollar ranges, seem to be of similar magnitudes to those reported by other industry observers. In both percentage and dollar value terms, the most serious food loss problems exist in the fresh beef and produce areas. This is especially true when

contrasted with the dry grocery category. In terms of the 1977 dollar values, losses are: fresh beef (\$510 million), produce (\$640-\$1262 million), and dry groceries (\$114 million). As is indicated in Table 1, dry grocery losses as a percentage of movement is very low; however, the category is such a large portion of supermarket food sales that the aggregate dollar value of losses is a substantial figure.

The aggregate figures showing the range of dollar food losses are enormous -- \$1.6 to \$3.2 billion. While such data may serve a useful purpose, they may also lead to the assumption of extreme and perhaps even willful wastefulness. This is generally not correct. It must be recognized that these highly aggregated estimates do not reflect the temporal and spatial dimensions over which losses take place. Neither are the magnitudes of individual incidents of losses conveyed in such data. Indeed, there are hundreds of thousands of trucks, thousands of food processing plants and distribution centers, and over 33 thousand supermarkets, all of which are the sites of individual losses -- 24 hours a day, 365 days per year. Moreover, the vast majority of individual loss incidents tend to be relatively small, frequently being measured in cents rather than dollars, to say nothing of aggregate systems-wide figures measured in the millions or billions of dollars. Thus, aggregate dollar values of food losses are not sufficient measures of the economic incentive for food loss reduction efforts, and may encourage misguided suggestions for loss reduction activities.

However, aggregate data on the magnitude of food losses may serve a useful purpose if they generate industry and public awareness of this important issue. Food loss quantities and costs, as large as they are, have the capacity to impress, if not shock readers. Some industry executives contacted during the study were surprised to learn the accumulated costs of food and related losses in

their operations. Indeed, some indicated that loss reduction behavior would be motivated by increasing management and employee awareness of the problem.

CAUSES OF FOOD LOSSES

Damaged merchandise, encountered in supermarkets as cartons are opened for shelf stocking and display, constitutes a large portion of losses occurring during distribution. In many instances, there is little evidence to indicate whether the product was actually damaged while in the supermarket, in transit to the supermarket, at the wholesaler's distribution center, in the food processing plant, during assembly after harvest, or at the time of harvest. Thus, exact locations and specific causes for individual food losses in the food system are often unknown. This uncertainty regarding the locations and causes of food losses contributes to the limitations of aggregate data. One reason for the relative absence of specific, published losses information is that standard accounting systems used in the food industry do not fully measure physical losses and associated costs. While it may be argued that benefits accruing from this type of information do not merit the investment, it was apparent throughout the course of this study that the amounts of food losses and their causes are only vaguely and imprecisely known.

Even though comprehensive information on the causes of food losses was not generally available, fragmented data coupled with industry interviews produced many useful findings. Specific causes for losses vary from one product category to another and even among products within the same category. The causes of losses also vary with different stages and activities in the food distribution system. However, at least one of four key causal factors can frequently be associated with food losses in the distribution system. These major factors are:

- (1) improper temperature and moisture control; (2) improper or abusive handling;
- (3) poorly designed packaging; and (4) ineffective management.

Certainly for each product and product category there are other important factors contributing to losses. For instance, in fresh beef distribution, cutting losses are significant, while in the case of produce distribution, losses from trimming are large. It should be stressed that factors leading to losses are often interrelated. For example, in beef distribution, central fabrication into subprimal cuts and vacuum packaging considerably decrease losses due to shrinkage in comparison with traditional carcass distribution systems. In this case, it is the combination of more efficient handling systems and superior packaging which reduces losses from shrinkage.

The fourth key cause of losses, ineffective management, deserves special attention. Management practices can either contribute to or reduce the possibility of losses from any of the other aforementioned factors. Loss reduction is enhanced by proper training of employees and heightening their awareness of the problem. Many times this is not done because management itself is unaware of the overall magnitude of food losses and the potential for reduction. It is an observation of this investigation that a significant reduction in food losses could be obtained with improved management practices.

The philosophy of food system managers and society, is highly receptive to the concept of food loss reductions. Since the beginning of this nation, one of the primary philosophical precepts has been the ethic of "waste not--want not." Despite the heavy emphasis on consumption in the U.S. society, this ethic is with us today and may become even more strongly held as people recognize the importance of conservation as a result of substantially higher energy costs and food price inflation.

In the course of this research, the proposal to analyze food losses was generally well-received by those approached on the subject. In not one instance did food distribution executives indicate that some food losses were too small to bother with, even though certain losses may have been less than one-tenth of one percent of the volume of food handled. There was a prevailing sense that any economically feasible reduction would be a useful improvement, no matter how small the net gain. It seems apparent that most people find food waste, as a concept, to be objectionable whenever and wherever it occurs -- be it in the strawberry patch, during food processing and distribution, or at the dinner table.

However, attitudes and behavior are not always consistent. When discrepancies between attitudes and behavior are confronted, people frequently advocate that behavior be changed to conform to the preferred ethic. Yet, one must realize that the "waste not--want not" ethic ought not be blithely applied to each occurrence of food loss.

LOSSES IN SEVEN FOOD PRODUCT CATEGORIES

The following sections provide summaries of findings in each of the seven food product categories examined in the research.

Fresh Beef Losses

Fresh beef is among the most important of U.S. food commodities. In a typical supermarket, fresh beef sales constitute between 35 and 45 percent of the total meat department sales, and 12 percent of total food store sales.

Fresh beef is distributed from the packer, either to the supermarket directly or through a distribution center operated by either a wholesaler or an integrated retail chain. Beef is also distributed in a variety of forms. In differing ways, a carcass is transformed in a disassembly process into various

sized units. Different materials and methods of packaging and handling are also employed. These differences in beef distribution methods bear importantly on the kinds and extent of physical losses which occur.

As fresh beef is distributed from packer to retailer to consumer, it is highly vulnerable to physical deterioration and losses. Beef is among the most perishable and biologically active foods. As such, its condition is strongly influenced by variations in packaging, lighting, temperature, humidity and sanitation. Both carcass and vacuum-packaged beef are sensitive to the physical handling to which they are exposed.

Another important characteristic of fresh beef distribution is the inevitable loss that occurs in the form of moisture shrinkage and cutting losses as carcasses are broken down into units to meet the shipping, storage, preparation and consumption needs of the marketplace.

This section focuses on four major kinds of fresh beef losses which occur during distribution activities: (1) shrink losses -- moisture evaporation; (2) cutting losses -- mainly in the form of "dust" resulting from sawing the lean as the carcass is disassembled; (3) floor scrap losses during the cutting process; and (4) retail and display losses at the supermarket.

Published data on losses for fresh beef transported by trucks is scarce. This is unfortunate as approximately 98 percent of the fresh beef marketed in the United States is shipped by tractor trailer. Losses typically occurring in transit result from mishandling and the evaporation of moisture from the meat -- shrink losses.

Data from consulting firms and beef processors were used to develop estimates on fresh beef losses during transportation. Losses due to physical damage during motor truck transportation are approximately 1 percent of the volume shipped. The most prevalent cause of shrink loss during transportation is

inadequate temperature control. One meat executive of a major supermarket chain stated that his company rejected 3 to 5 percent of all truckloads of carcass beef because of excessive internal carcass temperature. Improper temperature control seems to be the result of a combination of factors including faulty equipment, inattentive management, and an archaic distribution system which thwarts many loss reduction efforts.

Losses at the distribution center may be classified into three categories: shrinkage, cutting and floor scrap. Cutting and floor scrap losses result from the disassembly process and the removal of fat and bone. Cutting losses include the meat "dust," and the loss of meat which remains on the bones.

The severity of each type of loss varies with the method of beef distribution. With the exception of beef distributed in vacuum-packaged boxed beef form, the most common source of physical loss is shrinkage. In instances where carcasses are broken down into primals or subprimals at the distribution center, cutting and floor losses occur in addition to those due to shrinkage.

Causes of losses during wholesale functions vary according to type of operation. Some general causes appear to be: (1) sanitation practices which lead to bacterial degradation and reduced shelf-life; (2) prolonged exposure to the air which dries the product; (3) high temperature (greater than 32°F.) causing an increased rate of microbial growth; and (4) other causal factors associated with product deterioration.

Losses during supermarket operation can occur during any of the many supermarket functions, such as storing, cutting, packaging and displaying of retail cuts. Specific kinds of losses are those due to cutting, shrinkage, and those which occur in the handling of product for retrimming and repackaging.

As was the case in wholesaling operations, the extent and causes of loss during supermarket operation depends on the method of beef distribution. Losses

at retail can vary from 11.5 to 25.5 pounds per 650 pound wholesale carcass equivalent. Depending on the type of distribution method employed. The low end of the range represents the lowest loss levels achieved when beef is shipped in boxed form. On the other hand, the high figure represents the industry "norm" when carcasses are shipped to the supermarket to be fabricated into retail cuts.

The causal loss factors discussed relative to distribution centers apply to the supermarket setting as well. Sanitary conditions, exposure to air, microbial growth, and sources of contamination affect fresh beef in a similar manner in retail meat departments. More specifically, retail-level losses have been associated with several primary factors: product received at the store is of low "quality"; lack of refrigeration controls; retail meat cases are either inadequate or not utilized properly; inventory control problems; and lack of adequate sanitation controls. Additionally, boxed beef sustains losses which are unique to vacuum packaged and cartoned products. These losses result from perforated vacuum bags and are commonly referred to as leakers. They result from inadequate packaging or rough handling.

Causes of loss in supermarkets are related, in part, to the complexity of meat department operations. One indication of the difficulty encountered in retail operations is that as many as 500 perishable meat items may be handled by a supermarket.

The technology available to reduce losses at all stages of the distribution system is as varied as the causes of losses. There are many technologies currently available that would reduce fresh losses throughout the distribution system. Some of these, to mention a few, are: improved packaging materials to reduce moisture loss and afford better products; more efficient refrigerations units; and mechanically processed beef products. However, new technological developments are also needed to further aid loss reduction efforts. Some areas

where technological innovation would prove useful are: improved packaging design and refrigeration units; standardization of pallet and shipping container sizes to accomplish modularization; industry-wide standards for temperature and humidity levels for all stages of distribution; centralization of beef processing; the adoption of universal product code scanning; and better training and education of meat personnel.

Unfortunately, there are several barriers to the adoption of loss-reducing technologies in fresh beef distribution. For instance, the beef industry itself is highly traditional and resistant to change. Also, many groups, such as unions, have vested interests in the present system and in the short run, may be hurt by substantial change. At the present time, there is a shortage of capital necessary to adopt needed technology. Finally, some of the new technologies will mandate a change in consumer behavior in terms of products and purchasing practices. This barrier may be the most formidable obstacle to overcome.

Produce Losses

Following a decline since World War II, per capita consumption of fresh fruits and vegetables in recent years has shown signs of increasing. Purchases of fresh produce represented about 9.8 percent of supermarket food sales in 1977.

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. This project covered produce distribution activities ranging from the packer's or processor's shipping dock through transportation, wholesaling, and supermarket retailing operations.

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.

In general, a large proportion of produce losses result 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.

Industry observers estimate that in 1978 approximately 88 percent of all fresh fruit and vegetables were shipped to market by truck. The remaining 12 percent moved mostly by rail, and to a lesser extent by plane and ship. 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.

During transportation, packaging materials are subjected to considerable stress. Produce packaging does not always adequately protect its contents. The crushing of lower layer containers in stacks of produce is a packaging-related problem. Poor packaging can retard air circulation. Lack of cold air circulation slows the cooling rate restricting the removal of produce respiration heat.

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. The effect of inadequate temperature and humidity on losses during wholesaling activities cannot be overemphasized.

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.

Retail produce shrinkage data has 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 important cause of produce losses resulted from trimming vegetables in order to present attractive, salable products to consumers. A second cause resulted from discarded, unsalable 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.

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, overtrimming, and lack of proper stock rotation.

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.

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. Discussed below are broad remedies that have perhaps the greatest potential to reduce produce losses.

- 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.

- 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.

- The correct handling of properly filled containers can also 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, prepackaging of produce and palletization of products offer great potential.

- Improvement in transportation facilities and services will require an industry-wide effort, perhaps with trade associations, as well as 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.

● Governmental regulations and local ordinances regarding fresh produce require close scrutiny.

Dairy Product Losses

Six top-selling items from the supermarket dairy case were selected for primary focus in this study of losses and wastes incurred in dairy product distribution. The items are fluid milk, cheese, eggs, margarine, butter, and cottage cheese. In most respects, an understanding of the circumstances surrounding losses and wastes in the distribution of these six items provides a general overview of the loss and waste situation confronting the majority of products merchandised through the supermarket dairy department.

From the moment dairy products and eggs are produced, they begin to deteriorate in quality. Although there is little data on the extent of quality losses, numerous studies have been conducted which give valuable insights as to the fundamental causes of losses and remedies for their reduction. Genetic improvement and more effective storage operations have resulted in reductions in the interior deterioration of eggs. Temperature and humidity have been the two most important factors in controlling egg quality losses; and circulating cool air has been shown to be more efficient in the refrigeration of eggs than stagnant cool air.

For the most part, quality of dairy products purchased in retail outlets is high. There is evidence, though, that in some instances quality could be improved. Generally, so-called "mishandling" of milk and dairy products is the principal source of flavor problems. The most common form of mishandling is improper temperature maintenance. Shelf life is reduced when temperatures exceed 40°F.

There were few published findings on quantity losses of dairy products and eggs during transportation from the processor or packer to wholesaler. One reason for this lack of information may be that many agricultural products are exempt from Interstate Commerce Commission (ICC) regulations and transportation records are not required. In addition, transportation costs of many dairy products other than milk and eggs, historically constitute only about 2 to 3 percent of the retail selling price.

Although there were numerous causes for spoilage, breakage, and product deterioration among wholesale facilities, the two major causes -- excessive handling and inadequate refrigeration facilities -- were common to all. A range for tonnage losses of .5 to 1 percent of total volume handled has been established. This translates to total spoilage costs of about 5 to 10 percent of the wholesaling costs of dairy products and eggs. It has been suggested that new facilities could make significant contributions to the reduction of spoilage costs -- reductions of ranging from 16 to 54 percent. Most of these reductions would be achieved through less handling and by improved refrigerated storage facilities.

Losses also occurred in transit to retail stores from distribution centers. Although published data were not available, a Midwestern chain executive reported that, for some dairy products, as much as 80 percent of total loss incurred in all wholesale and retail activities might be attributed to this link in the distribution channels.

The main causes for loss during this activity were improper temperature control, inadequate packaging, and poor handling. Proper temperature control requires that the product's and the truck's temperatures be maintained at the appropriate level both during loading and transit. Primary and secondary containers that are not designed to withstand the level of stress placed upon them

during high volume, mixed-load shipping also contributes to transit damage. This was especially true for cottage cheese, yogurt and eggs.

A range of losses during supermarketing activities has been established at .13 to 2.50 percent. However, there is a great deal of variation within this range among retail operations and even among products. For example, one supermarket estimated losses on natural cheeses to be .25 percent of sales. At the other end of the spectrum, several supermarket department managers and a USDA study reported the breakage rate of eggs at approximately 3 percent of sales.

In general, because of its large share of dairy case unit sales volume, milk contributes more to losses within the department than any other item. Even so, most reported loss instances for milk were less than 2 percent of sales (less than \$86 million in 1977). The main causes for milk losses were inadequate handling and so-called out-of-date merchandise. When supermarket policies or local ordinances so state, milk that has reached its sales expiration date must be removed from display. These products commonly referred to as "stales", are typically destroyed, even though they may still retain their flavor, wholesomeness, and nutritional content at the time of expiration.

Viewing the dairy department as a whole, the three most prevalent causes for dairy losses appear to be: (1) inadequate temperature control resulting from refrigeration equipment failure or improper stocking techniques which inhibit cool air circulation, (2) out-of-date merchandise which, in most cases, was the result of improper stock rotation or mismanaged inventories reflected by over-ordering, and (3) rough handling resulting from inadequate employee training and motivation, poor equipment, and a general absence of management supervision.

It should be noted that the causes for losses and magnitudes of losses, as well as suggested remedies, vary from firm to firm and from store to store. One firm vertically integrated into milk and other dairy processing by assuming

ownership and management of the processing plant in order to gain greater control over the product. One result was reduced losses in the dairy department. The firm has also employed a computerized ordering system for fluid milk and thereby reduced losses through increased systems-wide efficiency. However, this is only one example of retailers' attempting to reduce dairy losses. Another method for achieving loss reduction was to purchase more efficient refrigeration units. It has also been found that better packaging by processors, such as paperboard or plastic containers, can reduce dairy losses at retail.

Dry Grocery Losses

Dry grocery sales account for the largest percentage of supermarket sales of any of the food product categories. The predominant mode of distribution for dry groceries is shipment via rail or truck from manufacturers to wholesalers' distribution centers, truck shipment to retail stores, and consumer purchase. However, some grocery items are delivered by truck to supermarkets from vendors and by direct shipment from manufacturers.

Losses in dry groceries are caused primarily by mishandling and/or packaging failure which results in broken, dented, ripped, crushed, or cut packaging. Incidents of spoilage of dry grocery items in the distribution channels are relatively infrequent.

These damage losses could be prevented, to some degree, by improved packaging; however, at times the packaging quality issue is a source of controversy between manufacturers and retailers. Retailers sometimes view product losses as a direct result of packaging failure; whereas, manufacturers may see the problem as being one of mishandling.

A number of other packaging and handling problems have caused controversy among manufacturers, shippers, wholesalers, and retailers. For example, innovations in packaging and packaging materials used in new ways frequently present

problems -- at least in the beginning. The replacement of glass juice bottles by plastic bottles is a case in point. Some plastic bottles do not possess the structural capacity to support the same load weights as their glass counterparts. Thus, when put in the same secondary container as glass and subjected to the same stacking weights, substantial losses due to leaking product have resulted.

Mishandling by human beings is, of course, the proximate cause of much damage in the distribution sector. To some degree damage is inevitable. Harried warehouse or supermarket workers will seek the easiest way to perform their jobs creating opportunities for mistakes and accidents; others may often be careless. Pressures exerted by the organization to increase productivity may also contribute to damages.

Losses during loading, transportation and unloading are frequently attributed to poor handling, which has many root causes. Generally, the more times goods are handled in the distribution channels, the greater the possibility for loss and damage. Another important characteristic of damage losses incurred during the initial transportation phases is that it frequently goes undetected until later in the distribution processes. This is the case since much of the damage is within secondary containers and is not visible until products are removed for display in supermarkets.

In wholesaling operations, constricted space creates increased opportunities for damage resulting from hitting, tearing, dropping, and similar types of physical abuse. Crowded conditions, themselves, are frequently a result of the need to fully utilize space, and to operate facilities at high levels of capacity. Unfortunately, the tradeoff is often increased damage.

In addition to wholesale inventory value losses and recoup room labor costs, indirect costs add significantly to the total costs of damage. Some of the more important indirect costs are: checking for damage during receiving, damage

clean-up, on-the-spot recoup, credit memos, supervisory time, and lost time for employees either causing or finding damage and accounting for damage.

Damage losses from dry grocery goods scrapped or sold at less than regular retail price has been estimated as .089 percent of grocery sales; spoilage loss at .017 percent of sales. Spoilage consisted of swollen cans, discolored glass-packed items, deteriorated candy, and customer returns of already opened products. Store-level recoup labor has been estimated at .014 percent of dry grocery sales. This estimate includes time required to sweep, mop up, and otherwise handle damaged items; however, it does not include employee time to move from the normal work station to the maintenance closet, to the site of damage and so forth.

Post-packaging losses of dry groceries, as a percent of total sales, do not appear to be as significant as losses measured in the perishable products categories, especially fresh beef and produce. As a percentage of items handled it does not appear that losses are exceptionally high. Indeed, when viewed as a percentage, it might be said that losses are relatively small. However, because the total dry grocery category is so large, in absolute physical volume, the economic importance of minimizing losses should not be underestimated. This is especially so in light of the fact that the achievement of loss reduction is within the capability of many organizations.

The causes of damage and traditional solutions generally are well known. This study revealed that human error, equipment inadequacy, and poor packaging are frequently the major sources of problems. In terms of solving these problems, materials handling equipment is continually being redesigned for improved efficiency. With regard to reducing human error, successful programs have been conducted and lend credence to the belief that such problems can be resolved

through the combined attention of manufacturers, transporters, wholesalers, retailers, and organized labor.

Inadequate packaging as a cause of damage, however, poses a different kind of issue. In general, products are priced to reflect costs incurred. This system should provide manufacturers with the economic incentive to reduce damage to their products. But since allowances and cash refunds for damaged product sometimes cover only 15 to 20 percent of the total cost of damage borne by retailers, manufacturers may lack incentive to improve packaging to the extent warranted. In some instances the economic signals being transmitted through the system back to manufacturers appear to be providing incomplete information, and in this situation there is a lack of pressure to resolve the issue of sizable losses.

In terms of achieving major breakthroughs, such as modularization of secondary containers and the performance rating of packaging, industry-wide efforts will be essential. These are not the kinds of changes that single firms or small groups of firms can accomplish alone. The tasks will be long and difficult, but results seem certain to be worth the effort.

Frozen Food Losses

The frozen food industry has realized substantial growth since the 1950s. Due to such factors as technological advances, production increased over 800 percent between 1950 and 1974.

The distribution channels for frozen foods are similar, in some respects, to those for dry groceries. Typically, frozen products are stored in manufacturer-owned or public frozen food warehouses at or near the processing plant. Some food products are distributed to regional distribution centers remaining under the ownership and control of the manufacturer, generally facilitating better service to wholesale distribution centers. The majority of frozen foods move

through the distribution channels by truck; however, some long distance shipments are made by rail.

Many of the same handling and packaging problems that beset dry groceries pose serious problems for frozens. The obvious and highly significant handling difference between dry groceries and frozens is that low and stable temperatures must be maintained for frozens throughout the distribution channels. It is clear that failure to maintain proper temperature is the dominant cause for losses among frozen foods in each phase of distribution -- transportation, wholesaling, and retailing activities.

There are several causes for inadequate product temperature during transportation. First, the products may not have been loaded at a sufficiently low temperature. Refrigeration units on most trucks are generally capable of maintaining acceptable temperature, however, they are not meant to reduce product temperature while in transit. This is especially true during the warm months. Second, truck refrigeration units may not function properly and may not hold temperature adequately. In some cases, drivers may shut the refrigeration unit down for a period of time in an attempt to save fuel. When loads are handstacked, and if the trailer is not ribbed, inadequate air circulation may cause portions of the load to "warm up". Fortunately, most of today's trailers are ribbed. This is especially important with the growing use of slip sheets. Slip sheets, of course, can be used to gain efficiency in handling without the loss of cube and the return problems characteristic of pallets. Additionally, however, when loads are palletized, poor air circulation is seldom a problem.

Causes for losses in the wholesaling operations varied. Exposure to potential temperature problems occurred primarily during unloading and loading at the distribution center and during delivery to supermarkets. Major problems occurred in unloading and loading operations when products were stacked on the

receiving and shipping dock. These dock areas were seldom refrigerated, thus temperatures may have ranged from 75°F. in the summer to 0°F. in the winter. In the distribution center, damage due to improper handling and packaging problems dominated.

Several factors were direct contributory causes of frozen food losses in supermarkets. These factors include: handling delays, equipment breakdown, overordering, faulty display stocking practices, abusive handling and packaging problems. Handling delays often are caused by backroom delays, where merchandise which has been unloaded and checked-in, remains in the backroom for excessive periods prior to storage in backroom freezers or stocking in retail display cases. Another delay, though often considered to be a wholesaling problem, was the delay of delivery trucks at the supermarket dock. These delays resulted either from dock space occupied by other delivery vehicles or by backroom space being unavailable to accommodate incoming merchandise. Whether this problem is primarily a wholesaling or retailing responsibility, solutions will probably require joint efforts on the part of the managements of both industry groups. In all delay situations causing losses, temperature standards are exceeded.

Clearly, temperature maintenance is critical to the preservation of quality in most frozen foods. For this reason many manufacturers, wholesalers and retailers have extensive temperature control programs. However, the enforcement of temperature standards is a systems-wide problem which is, at best, difficult to affect due to the sheer size and complexity of the food distribution system. Effective temperature control requires that substantial modern refrigeration equipment always be in proper working condition in both public and private warehouses and in thousands of trucks and supermarkets across the country. Well-trained and highly motivated personnel in each of the many transportation, wholesaling and retailing operations is another key factor relating to maintaining effective temperature control.

Finally, in addition to frozen food quantity losses -- losses in product mass -- frozen foods also suffer quality losses. Such subtle losses often go undiscovered in the distribution system itself. Even in the homes of consumers, it is likely that minor quality losses go largely undetected. But, certainly in many instances consumers realize when they have purchased an inferior quality product, even though they may not be able to identify its precise cause. They simply realize it is less than satisfactory. Such situations pose both short-term and long-term problems for the frozen food and related industries. Affected firms include growers of raw agricultural commodities, frozen food processors and manufacturers, wholesalers, and retailers since the success of each of these groups ultimately depends upon satisfied consumers. It seems likely that progress toward the reduction of both quantity and quality losses of frozen foods would be facilitated if the unmeasured costs of quality losses could be combined with the more obviously determined costs of quantity losses. This broader view of the cost of losses would provide greater economic incentives for loss reduction efforts.

Bakery Losses

In 1977 purchases of bakery products accounted for about 4.7 percent of supermarket sales. For the purpose of this study, perishable goods included: fresh bread and rolls, pastries and pies, donuts, cakes, fresh cookies, birthday and special order cakes, muffins and cupcakes.

The distribution channels for bakery goods differ depending upon location of manufacturing, and ownership of the bakeries. There are four main classifications of bakeries: central bakeries; commercial/wholesale bakeries; independent retail bakeries; and on-premise supermarket bakeries. Distribution channels for bakery products distributed through supermarkets generally are relatively direct as compared with those for many other kinds of foods. In the case of on-premise

supermarket bakeries, there are no wholesaling or transportation functions to be performed on finished goods. In several of the alternative distribution systems the transportation linkage goes directly from the bakery to the supermarkets. Transportation and wholesaling losses for bakery products are relatively low, and it is reasoned that the simplicity of the distribution system so often encountered is an important factor with respect to these low levels of losses.

Current trends occurring in the industry may be influencing losses associated with perishability. For instance, unwrapped bakery products are uncommon with the exception of items baked in on-premise bakeries; these items often are displayed unwrapped. Thus, the recent growth of scratch and bakeoff bakeries may be leading to an increasing proportion of bakery products with the relatively short shelf lives of the unwrapped items.

Another trend which may be adversely affecting losses is the rising popularity of "variety breads" as indicated by substantial increases in the sales of items such as rye, pumpernickel, whole wheat, butter twists, etc. This increasingly segmented market for breads has created the difficult task of managing adequate inventory levels for a larger number of products, resulting in a situation where losses on each kind of bread may be increasing somewhat. Thus, it is hypothesized that consumer preferences for a broader variety of bakery products is perhaps leading to increased losses.

The bakery subsector reference to losses, regardless of cause, is "stales". Stales, then, refer to losses resulting from out-of-date products. Although stales generally represent a significant economic loss, they do not necessarily represent a large loss of food for human consumption. Some retailers and commercial bakeries have large-scale price mark-down and day-old bread store operations as a means of distributing products for human consumption. In the cases of

discount programs, day-old bread store outlets, and reprocessing into other food products, losses of bakery products for human consumption are very small.

Economic losses accompanying bakery stale rates varied with the particular method used for disposing of the stales. For example, one supermarket organization made extensive use of day-old bread stores and reduced a 9 percent stale rate to a 7 percent economic loss; however, the loss of food for human consumption was reduced to only about 1 percent. This illustrates that while losses of food for human consumption can be kept relatively low, economic losses tend to remain fairly close to the stale rate. In those situations where stales were either discarded or used for animal feed, economic losses were only slightly larger, but losses for human consumption increased substantially.

The causes of bakery losses are somewhat more limited in scope than are the causes for losses in many other food categories. For example, one firm indicated that approximately 70 percent of stales resulted from a combination of over-ordering and unpredictably slow shopping demand. Another 25 percent of the stales resulted from inadequate servicing of displays. The remaining 5 percent of stales resulted from other causes, such as crushing or otherwise damaging products either by store personnel or shoppers.

Several remedies for reducing in-store losses of bakery products have been suggested. In many instances supermarket bakery departments suffer from a lack of effective management. This situation has its origin in traditional practices. Historically, the bakery department has been served by direct store delivery vendors who, to a large extent, cared for the products and assumed the direct economic losses resulting from stales. However, as the role of retailer-owned central bakeries has expanded and as in-store bakeries have grown in popularity, the economic losses for retailers and the potential for economic gain from close management have increased. Thus, a frequently heard suggestion for reducing

stales and improving overall performance of the bakery department was to move toward greater professionalism of in-store management. In some instances this meant creating the position of bakery department manager.

Another key suggestion for reducing bakery losses was to improve store ordering mechanisms. Many industry spokesmen believe that this could be accomplished through improved sales information and perhaps greater use of computerized ordering systems. It appears that UPC Scanning data would have invaluable applications in this area.

Delicatessen Food Losses

All supermarkets carry some delicatessen foods and in recent years there has been substantial growth in the numbers of supermarket deli departments. There is a wide variety in the number of foods sold as deli items and in the way they are merchandised. Luncheon meats, for example, may be merchandised through meat departments just as cheeses and ready-to-eat salads may be offered to shoppers in dairy departments. Increasingly, however, deli foods are being displayed and sold in formal deli departments which are independent of other departments within the supermarket.

Due to the wide variety of deli foods, the causes of food losses in the deli vary widely. For instance, some forms of canned hams and sausages suffer from the same causes of losses as dry groceries. Fresh, bulk deli salads, on the other hand, have similarities to both produce and dairy items. These foods require careful handling and controlled refrigeration to keep bacterial spoilage at minimum levels. The following list of basic causal factors are related to deli department losses: handling; temperature and humidity; slow demand; spoilage; packaging materials and processes; moisture evaporation and shrinkage; government regulations; limited product life; out-of-date; sanitation; inventory management; and, quality of product entering distribution channels.

The most important loss factors in this list relate to the inherent perishability of many deli products and the unpredictability of consumers' shopping demand. The inability to predict shopping demand arises from such factors as the substantial seasonality of product sales, and the effect of day-to-day weather patterns. Holiday and weekend sales of deli products are especially susceptible to adverse weather conditions.

Field interviews with a limited number of Midwestern retailers indicated that losses in transportation and wholesaling activities were relatively small. During these stages of distribution, losses for a cross section of deli foods were reported to be less than .25 percent. Several factors may help to explain the relatively low level of losses. First of all, many products are delivered directly to the supermarket from nearby, specialized manufacturers and vendors; or from central, retailer-owned commissaries. Also, final in-store preparation of certain deli items contributes to low transportation and wholesaling losses. Finally, perhaps it is recognized that many deli items are relatively perishable and high in value, thus the economic impacts of losses are appreciated and special care is exercised to avoid losses during transportation and wholesaling activities.

Unlike transportation and wholesaling operations, deli losses during supermarket activities are substantial. High perishability, variability of shopping demand, required re-working and trimming, and necessary sanitation standards combine to make loss reduction of deli items a significant challenge. Based upon interviews with midwestern retailers, estimates of service deli retail shrink loss ranged from 5.16 to 7.75 percent. In this case, shrink loss is defined as the difference between expected and actual sales dollars. This figure, therefore, includes such factors as theft, markdowns, accounting errors, and cashier error as well as losses of food for human consumption. Related estimates of

tonnage losses -- that portion of losses that reduce the quantity of food available for human consumption -- ranged from 3.23 to 4.75 percent.

A number of techniques are used in efforts to reduce or minimize losses during supermarket operations. First, proper ordering procedures coupled with adequate inventory control practices seem to be key factors for reducing losses. Secondly, it was noted that proper sanitation is extremely important, and that inadequate sanitation and product losses are directly correlated in the deli department. Another method for reducing loss is to frequently re-merchandise the deli counter to match retail demand with allotted sales space. Since demand may change with the seasons, to maintain appropriate inventories and minimize loss, it is necessary to modify product selection and space allocation with each change of season.

ECONOMIC ISSUES RELATING TO FOOD LOSSES

Certain economic conditions and issues are discussed here that must be considered if society is to benefit in an overall sense from food loss reduction efforts. After consideration of these economic principles, it may become more apparent that in some instances it is to society's benefit to accept as rationally tolerable a certain level of food losses rather than to completely eliminate them.

Consumers desire an adequate supply of wholesome food that is taste appealing, nutritious, and available at reasonably low prices. At the same time, food firms and individuals whose livelihoods are dependent on participation in the food system desire an equitable return for their efforts. Society expects a high level of efficiency in utilizing the nation's resources -- of which food may be considered one. The attainment of these objectives is laudable and they are not necessarily mutually exclusive, but their accomplishment must be based on sound

economic principles. In attaining any set of performance objectives, there may be instances where trade-offs occur. For example, it is possible to provide consumers with a completely nutritious meal at a very low cost. However, such a meal may be extremely bland and unexciting. The following discussion highlights key economic principles as they may be applied to questions of food losses and suggested approaches for reducing them.

Theoretical Nature of Market Failure

Frequently, food losses encountered at one point in the system are caused by circumstances occurring elsewhere in the system. Unless coordinating mechanisms are instituted to comprehensively analyze the complex interrelationships of the food system, loss reduction is likely to be only partially successful. In some instances, the traditional ad hoc approach to food loss reduction may contribute to even greater losses from a total system perspective.

Currently, few institutions exist that have systems-wide coordination as one of their goals. Yet in their absence, greater coordination and cooperation necessary for the efficient functioning of the total market is unlikely. Several examples may be cited, however, as universities, government and industry organizations strive for greater effectiveness.

The North Central-117 Project is but one example in which several Land Grant Colleges have coordinated research efforts to perform more comprehensive analyses of certain food systems topics. The now-defunct National Center of Productivity and Quality of Working Life began important projects, serving as an effective coordinating mechanism. The non-stop, unit produce train from California to the East Coast is but one example of many projects it sponsored. The Department of Commerce has been in dialogue with a number of food distribution company and trade association executives exploring the feasibility of establishing a productivity center. The center would use government funding in

conjunction with industry resources to establish a consortium to address the problems of lagging productivity in the food system. The U.S. Department of Agriculture which has conducted loss reduction research has an almost limitless potential to exert great initiatives in this respect were it to more fully recognize the need to do so. The reality of improved problem-solving coordination may also be served through the participation of industrial organizations which produce equipment and systems purchased by food systems firms. It seems logical, for example, that coordinated loss prevention projects should include manufacturers of refrigeration equipment, transportation facilities, mechanized distribution center equipment, computer machinery and systems, accounting services, home storage and preparation appliances, packaging materials, and the like.

Applying Cost/Benefit Analysis

Benefits derived from loss reduction efforts must exceed costs. This is the most basic economic condition to be fulfilled if society is to gain from food loss reduction activities. The cost/benefit principle, as applied to food losses, can be expressed as follows: The value of the benefits which accrue from an effort to reduce losses must exceed the costs of achieving them. Thus, it is necessary to determine dollar values for the benefits and to establish dollar costs for the reduction effort even though this may be very difficult to accomplish. For instance, issues such as "quality of life" and the "equity of outcomes," create serious problems when evaluating costs and benefits; however, factors such as these should be considered in the cost/benefit analysis. In the context of reducing food losses, if the dollar costs of reducing losses are greater than the value of all resulting benefits, then it will be in society's best interest to continue to tolerate the loss.

An important goal for our food system is that of achieving a high level of efficiency in all operations from the farm to the consumer. There are several definitions of efficiency, but here systems-wide efficiency refers to the movement of food through the distribution channels at the lowest possible cost consistent, of course, with other performance goals of ethical business practices, food wholesomeness, sound nutrition, and the like. If overall food distribution efficiency cannot be improved by reducing losses, it will be more useful to devote effort to some other purpose where results may be of greater value.

An illustration of this notion relates to energy. At the present time, it may make more sense to devote effort to reduce energy utilization in the food system than it does to reduce food losses. However, economic analysis must be dynamic to be truly useful. As conditions and prices change over time, so will the economic viability of certain alternatives. Although it may not have been economically justifiable to make greater investments in food loss reduction in the past, with changing conditions it may be appropriate to do so now, or next year, or five years hence. The benefit-to-cost ratio can change dramatically over time as technologies change and as the relative prices of resources vary.

Minimizing the Cost of a Single Resource

It is seldom possible to maximize overall systems-wide efficiency by minimizing a single cost. Food, as it moves through the distribution system, can be viewed as both an output and an input resource. In this sense, food is an "intermediate good." Viewing food as a resource is beneficial when conceptualizing a benefit/cost analysis for the reduction of losses. This viewpoint brings into focus the idea that food is but one of many resources employed to accomplish the broad objectives of the food system. System-wide efficiency in the food system is concerned with the attainment of minimum total costs for meeting the

food needs of our society. The cost of losses incurred while moving food through the system is but one of these costs. Society must be concerned with overall system efficiency; the costs of all resources including labor, energy, equipment, and capital, as well as food losses. Efforts to minimize food costs without regard to the costs of other resources may, in fact, increase total costs.

To illustrate this notion, consider the technical possibility of almost totally reducing egg losses incurred during distribution through elaborate and expensive alteration of packaging design and egg handling procedures. However, the savings derived from the reduction in lost eggs may be more than offset by increased packaging, transportation, refrigeration, and handling charges.

Distinguishing Between Physical and Economic Losses

When analyzing food losses it is important to avoid equating physical food losses with the economic costs of those losses, since not all physical losses bear an economic cost. Moreover, not all economic costs of food losses are contained in the value of the physical item which has been lost. In some instances, it may be advisable to accept a certain level of physical losses in order to minimize food costs. The effort to retrieve the last ear of corn from a field, for example, may cost more than those few kernels are worth.

To illustrate that physical losses do not necessarily result in economic losses, consider the situation of farmers. In bountiful seasons when harvests are large and there are large quantities of product available for the market, unit prices received by farmers are generally lower, and their income may suffer. In years of short crops, farmers receive higher unit prices which may be reflected in increased net income. Thus, it can be seen that reductions of food losses at the farm level which lead to increased supplies could actually decrease farmers' aggregate income. In this light, farmers, as a group, have little

incentive to reduce food losses. In abundant crop years, it would be to farmers' collective benefit to have a portion of the total crop go to waste. In this case, food losses on farms in aggregate could lead to higher farm income. It must be added, however, that this principle which applies so well to farmers in an aggregate sense does not apply to farmers acting individually; and that, in fact, most decisions in the U.S. farming sector are conducted on an individual basis.

The economic costs of food losses are not fully accounted for in the costs of physical quantities lost. For example, the costs of products damaged at distribution centers or supermarkets represent only a portion of the total costs of damage, since clean-up and salvage operations must also be included. Indeed, economic costs of food "losses" can occur without the disappearance of food from the system. Bread that is not sold by a retailer may be sold at below cost prices through "day-old" bake shops; or the bread may be used for animal feed or another lower value use. Although the bread is consumed in each instance, the retailer has obviously suffered an economic loss.

Consumer Acceptance of Loss Reduction

When products, services, and marketing philosophies are modified for the purpose of reducing losses, they must meet with consumer acceptance. A fundamental precept of our economic system is that the consumer is sovereign. A goal of the food distribution system is to fulfill the preferences of consumers as articulated by their action in the marketplace. To the extent that this goal is achieved in practice, consumer sovereignty determines the success of any loss-reducing innovation which is implemented. An alternative method of distributing fresh beef, in frozen form, is a case in point. According to some studies, frozen beef is an economically feasible method to reduce beef losses. However, consumer acceptance of frozen beef has yet to be established; and for this reason, frozen beef systems have been rejected by the industry as a viable means

to reduce losses. Another example of a loss-reducing technology is vacuum-packaged fresh beef. This product presents the shopping public with a dark purplish color rather than the bright red "bloom" to which shoppers are accustomed. At this time, it is not clear whether or not consumers will accept this "different" product.

A relatively common marketing practice which conflicts with the goal of food loss reduction is the over-stocking of supermarket shelves and display cases to avoid lost sales due to out-of-stock situations, as well as to create attractive merchandising displays. Such practices increase the instances of deterioration and losses in bakery, dairy, frozen food, produce, and fresh meats. However, they are also thought to maximize sales, as well as to reduce the risk of lost sales -- considerations of utmost concern to most retailers.

Motivation to Reduce Food Losses

Reduction of food losses, per se, is not likely to be the sole motivating force behind broader efforts that do result in reductions of losses in the food system. In the past, changes in the food system to enhance efficiency have decreased food losses in some cases, and actually increased losses in others. Furthermore, those changes which have increased specific instances of food loss may have been economically defensible, on the basis of overall, system-wide efficiency improvement.

One result of increased vertical integration and coordination within the dairy processing and distribution sectors appears to have been a reduction in dairy product losses resulting from better coordination of activities and reduced handling. However, the principal motivation for increased vertical integration did not rise out of a singular desire to reduce food losses. Rather, the driving forces were a desire for greater efficiency in ordering procedures and improved quality control.

Compliance With Food Wholesomeness and Safety Regulations

A compromise generally exists between minimizing losses and meeting other goals such as product safety and wholesomeness regulations, employee safety standards, and food company quality assurance policies. For example, regulations can result in losses of food for human consumption. However, such losses may be justified by reducing the risk of adverse effects on consumers' health and welfare. The sales expiration dates on milk, for instance, may lead to destruction of product. The issue is complicated by the reality that if such milk had been purchased and consumed immediately following the expiration date, it would in all likelihood have been safe for consumption as a flavorful and nutritious food product.

Some level of economic costs (including food losses) expended to achieve reasonably low levels of consumer risk are generally accepted as necessary and desirable. However, in part, because the value of consumer benefits resulting from reduced risks are so difficult to measure, there is often controversy in our society regarding appropriate levels of effort and cost which should be devoted to reducing risk. Perhaps even more fundamental, there exists a growing dilemma with respect to what constitutes an appropriate level of consumer risk. Additionally, it is argued by some that inadequate opportunities exist with respect to consumer choice in this matter. Clearly, public policy is often in conflict with food industry organizations concerning the issue of appropriate levels of consumer risk.

REQUISITES FOR LOSS REDUCTION

Economic considerations notwithstanding, there are a number of requisite occurrences and activities which will facilitate, and indeed, may be necessary for the achievement of substantial food loss reductions. A number of major requisites are discussed below.

Awareness and Measurement of Losses

For food systems' managers, government officials, university researchers, consultants, and the like -- to take action toward the reduction of losses they must first become aware of the losses problem. This is a basic notion, but one that is of primary consequence.

How can it be explained that there is a lack of awareness regarding food losses? No function in the food system, or in any industry for that matter, is operationally perfect; free of friction or loss. It may be that one tends to view the contemporary system in which one operates as acceptable, if not perfect. For example, fresh beef operators may unconsciously view the 2 or 3 percent shrinkage which beef experiences as an inevitable reality; a loss which is normal and acceptable. However, when one becomes aware of an existing technology, such as vacuum-packaged boxed beef, that can almost totally eliminate shrink loss, then the normal, routine evaporation must be regarded as a "loss." Thus, awareness of the loss has been achieved; and the primary prerequisite for action has been established.

Enlightened awareness usually will not result without substantiated facts. To be fully perceived, food losses must be measured in believable and useful ways. Earlier discussion of economic issues emphasized that costs occur not only in terms of dollars, but also in esthetics, quality of life considerations, taste and flavor, healthfulness, or whatever other criteria are chosen. With respect to assigning costs in the food system, one might first begin by formulating a rank-ordering of the roles food is to play for principal groups of persons that constitute society--consumer segments, if you will. For instance, food may fulfill the roles of good taste, attractive cosmetic appearance, nutrition, convenience, a source of entertainment, an indicator of status, and so forth. Thus, a prerequisite for loss reduction is that of defining losses and establishing criteria for their measurement.

Communication of Economic Incentives

Appropriate economic incentives to reduce food losses must be accurately transmitted to decision makers within the food system if loss reduction activities are to be implemented. In some cases, accurate economic incentives to reduce food losses are not transmitted to those food system organizations which have the opportunity to initiate changes to reduce losses. For example, many losses discovered in each phase of food distribution; transportation, wholesaling, and supermarketing, can be attributed to inadequate packaging. In such cases, the food manufacturer or processor has the opportunity to improve packaging and reduce losses, but frequently at the expense of higher costs. However, manufacturers may not appreciate the full economic consequences of inadequate packaging. Such is the case even when manufacturers are required to reimburse retailers for the costs of the food items lost, since the true cost to retailers may consist not only of the cost of the item, but also of the less conspicuous costs of clean-up and the collection of reimbursement from the manufacturer. If the sum of all associated costs was transferred to food manufacturers, sufficient economic incentives might then exist to motivate them to upgrade packaging, even if it costs somewhat more. In essence, if the full economic costs of losses due to inadequate packaging were borne by manufacturers, then most likely they would be willing to spend more to improve the quality of packaging in order to reduce losses.

Commitment to Change

Changes in the way food is processed and distributed are derived mainly from the myriad of decisions made by businesses responding to economic incentives as they perceive them. Change, however, is also fostered by regulations, public demand, and other factors to which food system participants respond in complex

and varied ways. Thus, the accepted method of change in the food system is gradual and relatively free of direction by government, universities, associations, consumer groups, unions, and the like.

Just as society now has come to view certain aspects of the energy problem as issues which must yield to greater centralization of analysis and leadership -- perhaps to be accompanied by directives for rapid and even radical change -- it might also be possible for the growing and related issues of food systems productivity, losses, and overall efficiency to be approached in a similar manner.

A societal consensus of this kind is likely to occur only if leaders, especially those in industry and government, persuade the public to view the many issues of food systems efficiency as critically important causal factors underlying food price inflation -- a leading contributor to overall price inflation which is this nation's greatest economic problem.

The Role of Research

In addition to the above cited requisites for loss reduction, research can also play a vital role. In fact, research may be crucial in meeting these requisites. It should be coordinated to include the involvement of all participants in the food distribution system. Only in this way can the complex interrelationships which lead to food losses be analyzed from a systems-wide perspective.

Most researchers of food losses have given special emphasis in their reports to the pressing need for additional research; research which is much more comprehensive in nature. The need for a "systems" approach to research is a theme common to many reports. Our analysis of available literature, and limited supplemental fieldwork causes us to underscore the validity of this singular observation. Small-scale analyses of single instances of losses fall far short

of the benefits that can accrue from studies that trace factors relating to losses both up and downstream in the food channel. The following citation from a recent research report on food losses underscores the need for further work in the area. The 1977 General Accounting Office report, Food Waste: An Opportunity to Improve Resource Use, makes this concluding point (p. 47):

Food loss in the United States has been estimated to be of considerable magnitude, although there is a lack of comprehensive system-wide data on it. Every segment of the food system is affected . . . The subject has been given insufficient attention, a situation which calls for remedial action.

It should be stressed that more research, per se, will not be the key to progress in loss reduction efforts. What is required is more research that: (1) analyzes the food system vertically; and (2) is sufficiently broad to take into account logical groupings of similar products which are handled in similar ways. Moreover, the organizational/institutional setting at each stage of the food system must be taken into account.

Assuming that high quality research will be conducted, the results must be disseminated and implemented. Existing and perhaps new means for extending technology to potential users will need to be utilized. The State Extension Services, in cooperation with the U.S. Department of Agriculture, is an existing mechanism which has the potential to participate in this endeavor. However, unless it expands its traditional role to go beyond production activities in agriculture, it may be necessary to encourage food firms themselves to greatly expand their role in the dissemination of information. The institution of a national center for improved food productivity to coordinate research activities and act as a catalyst for system-wide change may be necessary.

LOSS REDUCTION: NO EASY ANSWERS

As is so often the case, when system-wide changes are made, not all sectors benefit commensurately with the investment made or inconvenience suffered. A

generally acknowledged goal for the food system is equitable reward and treatment of the system's participants. Where changes involving increased costs for one sector of the food system are made to reduce losses and costs in another, mechanisms exogenous to the food system may be necessary and deemed appropriate to foster change. Various mechanisms may be considered, including direct subsidies, tax incentives, and so forth.

As food system participants implement changes to reduce losses and costs, organizations should prepare themselves to accept the possible paradoxical phenomena which may occur. Some changes of a radical nature leading to improved long-run food systems performance may initially cause increases in physical damage and losses. Such losses may persist until organizations are able to master newly implemented techniques and practices. Implementation of vacuum-packaged boxed beef, and mechanization of distribution centers provide only a few examples where considerable time has been required to overcome relatively high break-in period costs. Managers should realize that increased losses may be an inherent part of the process of change and progress. A long-term perspective by decision makers with respect to this issue is essential.