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Some Factors Affecting Quality of Product and Retail Costs of Handling Beef

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SOME FACTORS AFFECTING QUALITY OF PRODUCT AND RETAIL COSTS OF HANDLING BEEF*

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TABLE OF CONTENTS

SOME FACTORS AFFECTING QUALITY OF PRODUCT AND RETAIL COSTS OF HANDLING BEEF

Consumers in the United States use about 24 billion pounds of beef annually. This beef is processed and distributed largely through retail food stores in packages ranging from one to ten pounds. While some beef is sold in carcass form or through service type outlets, the major quantity is handled in prepackaged form through self-service outlets. Most beef is sold as fresh meat within three to four days of first being displayed, and one to two weeks from the time of slaughter.

While a fairly uniform system of handling is employed by retailers, there is considerable variability in detail. Systems of handling and cutting, including methods of sanitation, vary. Temperatures used in storage, cutting and display areas differ from store to store. Methods of wrapping, displaying and handling of the meat vary as do general inventory policies. In-store practices of handling beef, as well as the characteristics of the base product, are known to affect the shelf life and retailing costs.

This study is concerned with the factors affecting the keeping quality of beef in the store and the economic costs associated with losses observed through certain store operating policies.

PROCEDURES

Essentially, the study was comprised of two phases. The first phase involved the collection of data from a sample of stores in a local food chain. Both economic and technical data were collected on the beef cuts handled by the stores. Additionally, technical data were collected from an experiment carried out in the store display cases.

The second part of the study involved experimental tests on selected cuts of beef in a controlled environment. Recordings were taken of shrinkage, microorganism growth, and certain other characteristics associated with different temperatures, time spans and marbling scores.

STORE TESTS

Economic Aspects

Data were collected over a ten-week period in the fall of 1971, from four meat markets in the Tucson area. The specific objectives were as follows:

(1) Determine costs associated with the shrinkage of meat from the day of delivery until the time of sale.

(2) Determine costs associated with the deterioration of meat on the display shelf including spoilage, reduction in quality and costs of repackaging, repricing and other associated activities.

The four stores visited are referred to as A, B, C, and D in this report. These stores were selected by the management of the cooperating food market chain. They were in different geographical locations within Tucson and served people in various income levels. Store A served an area in the city composed primarily of relatively high income residents. Store B served an area consisting of both high and middle income families. Store C was located in a predominately middle income area and Store D was located in a low income area.

Stores A and B were similar in characteristics with relatively modern equipment and refrigeration systems. Stores C and D were older with poorer refrigeration systems. Store D operated as a lower priced discount store handling a lower grade of beef.

All four stores had a general policy of keeping meat in the display case for a maximum of 3 days. Two of the stores maintained special display sections for meat sold at discounted prices after the third day. The other two stores merely repacked and/or repriced the meat, leaving it in the display case with fresher cuts.

Handling Methods and Losses on Primal Cuts

Department managers were faced with the problem of maintaining an inventory of meat sufficiently large to maintain sales and at the same time minimize losses due to deterioration and shrinkage. In the sample stores, managers placed beef orders on Monday for delivery the following Thursday and again on Thursday for delivery the following Monday. Carcasses were usually broken down into primal cuts during the day of delivery or on the following morning. Primal cuts were hung from one to four days before being cut and wrapped for sale. Carcasses were normally reduced to the following cuts:

1. Round
2. Loin
3. Chuck
4. Rib
5. Sirloin Tip
6. Shank and Brisket
7. Plate
8. Flank

Loss due to shrinkage was determined by weighing the primal cuts (less the trim and waste) at the time the carcass was broken down and at intervals ranging from daily inspection for a period of six days to a single observation three to four days after the primals were first hung.

The first and second days of hanging for primal cuts accounted for about 60 percent of the shrinkage observed. The average shrinkage for primals left hanging for a period of six days showed a total loss of approximately two percent with nearly 80 percent of this occurring in the first three days. The average shrinkage based on three-day test weights was 1.8 percent with a range from 1.26 to 2.23 percent of the total weight.

On 1,400 pounds of primals, hung for three days, the total shrinkage loss was estimated at 24.5 pounds. For 767 pounds of primals hung six days, the weight loss was 15.6 pounds. Based on a carcass cost to the retailer of 60 cents per pound and an average weight of 250 pounds per side (cut and trimmed), the loss per carcass, assuming a 3 day hanging period, was estimated at $5.40. Assuming a turnover rate of 10 carcasses per store per week, the loss would amount to $54 or approximately $2,800 per store per year. (Based on higher price levels of 1973 and 1974, these losses amount to approximately $3,500.)

Temperature and humidity are known to be important in determining the degree of shrinkage occurring in the cooler. The recommended temperatures for the walk-in coolers are in the range of 34° to 36° F [1]. The stores visited appeared to maintain these temperatures during hours when the stores were closed, but during business hours temperatures in the coolers rose above the recommended levels. The increase in temperature was due to the opening of the doors of the cooler in taking deliveries and in moving the meat to the cutting room. It is suspected that the temperatures of the coolers in all of the stores reached approximately the same level at some time during the day.

The refrigeration system must reduce temperatures quickly in the area after activity has ceased and maintain them at desired levels in order to reduce shrinkage in the coolers. It is at night and early morning when more efficient systems can make a difference. One of the sample stores was equipped with a more efficient cooling system for the areas in which meat was handled, i.e., the cooler, the cutting room and the display case. This store had 1.76 percent shrinkage after the six day test as opposed to 2.13 and 2.22 percent shrinkage at the other stores. Although random differences may explain some of the variation in percent shrinkage, it suggests that keeping the cooler within the recommended range of 34° to 36° for a greater period of time contributed to a reduction in shrinkage. If temperatures can be maintained via better management or more efficient equipment, a saving should result. If more investment and/or more power were involved, the cost would need to be balanced against added savings. A possible alternative, to reduce losses using existing facilities, would entail wrapping or bagging the primals with an appropriate material to keep air from the exposed areas of the primals.

Results of a test by the Texas A & M Agricultural Experiment Station showed that beef primals which were vacuum packed, boxed, and stored for ten days yielded 3.7 percent additional product available for retail sale than primal cuts not packaged but stored for the same period of time. Primal cuts stored in boxes after vacuum packaging lost 0.25 percent as shrinkage and 3.4 percent as trim from the surface of exposed lean, whereas primal cuts stored without protection lost 1.1 percent as shrinkage and 6.2 percent as trim from the exposed muscle surface. Thus shrinkage and trim losses were 3.7 percent higher for the unpackaged primals. Assuming a carcass of 500 pounds, the additional loss would amount to 18.5 pounds or $11.00 per carcass at 60 cents per pound. No costs for the vacuum packaging and boxing were given [2].

Another alternative is to process the meat for sale immediately after the carcasses are broken down. This would reduce the time of exposure to the air. The procedure followed when the survey was being conducted called for the carcasses to be cut into primals, all at one time, and left hanging until needed. This was usually done on a "slow" day when the turnover in the display case was lower. This allowed one man to break the carcasses and the other man (or men) to cut and trim the meat for wrapping and sale or storage for use later in the day or possibly early the next day. On days when turnover in the display case was greatest ("special" day and weekends) it was difficult to release a man to break down the carcasses and still be able to keep up with cutting and trimming. If supply in the case is inadequate sales are affected.

Losses from Deterioration in Retail Meat Cases

It is generally recognized that discolored and deteriorated meat in the display case is not acceptable to the customer. This meat must be moved from the display case and reprocessed to improve its appearance or its price must be marked down enough to persuade the consumer to buy it in less than optimum condition. Reprocessing increases operating costs directly and reduces revenues. If sufficient deterioration occurs, the meat may have to be discarded as indicated earlier. The general policy of the sample stores was to keep meat in the display case for no more than three days. Cases were inspected twice daily and any package lacking a saleable appearance was withdrawn and reprocessed or repriced for discount sale. Since there was almost no reprocessing and little discarded meat, the special sales system was an effective disposal method.

Two of the stores had special sections near one end of the display case for marked-down items. All types of meat were placed in the discount section. The other stores simply placed the marked-down items among similar cuts displayed in the main area of the case. No significant difference in movement of discounted packages was observed between the two methods.

The use of the discount section, however, entailed more time. The cuts removed had to be selected, marked, and transferred to the special section, usually some distance from the main beef section, whereas the other method required only the selection and repricing of the items in the display case. For the latter, the only movement of the cuts was involved in pricing and in bringing them to the front of the section where they were more readily seen by the customers.

The estimated time spent working with "pull-backs" varied from 20 to 35 minutes per day with an average of 30 minutes. The stores using the discount section discounted an average of 7.4 pounds per store per day. Each estimated his time spent with "pull-backs" at 20 minutes per day. The stores not using the discount section discounted more meat per day, averaging 20.2 pounds total and required 30 minutes to do the work.

Assuming the "pull-backs" were handled by a wrapper receiving an hourly wage of $3.05, the cost to the stores using the discount section would be $1.02 per day per store, or approximately $367 per year per store. The cost to the stores not using a discount section would be $1.52 per day per store, or approximately $547 per year. If the meat manager handled the "pull-backs", the costs would be proportionately higher.

In addition to the costs associated with handling and marking the discounted meat, the loss in revenue for marking the meat down from its normal selling price was considered. To determine the amount and percentage loss associated with the discounted meat, information on the daily number of packages cut and wrapped, the weight and number of packages discounted, and the price differentials on each package pulled was obtained from each store. The average weights of the packages of the different cuts were determined by taking an inventory of the meat in the case. The number of packages of each cut, the weight of each package, and the price per pound of each cut (Appendix Table 1) was recorded and averages were determined. The results with estimated losses are summarized in Table 1.

Store management policy on handling and pricing of discounted cuts affected individual store costs. Differences in the amount discounted for similar cuts are summarized in Table 2.

Store D had the highest percentage of "pull-backs" in the sample (Table 1). The average amount pulled back per day amounted to 17.9 pounds or 2.7 percent of the daily volume of 652 pounds. The loss associated with the "pull-backs" and repricing averaged $2.95 per day or 0.49 percent of the total value of the meat processed.

Table 1. Daily Volume of Beef per Store with Estimated Discounts.

Item	Store A	Store B	Store C	Store D	Four Store Totals
Average sales per day, pounds	458	913	1,096	652	3,119
Average value per day, dollars	455	940	1,161	608	3,164
Average weight "pull-backs" per day, pounds	9.6	5.2	22.5	17.9	55.2
"Pull-backs" per day, percent of pounds sold	2.10	0.57	2.35	2.74	1.77
Discount per day, percent of total dollars sales	0.36	0.15	0.65	0.49	0.43
Projected "pull-backs" per year,[a] pounds	3,456	1,872	8,100	6,444	10,872
Projected loss per year[a], dollars	483	500	2,736	1,062	4,882

[a] Year equals 360 days.

Table 2. Average Discounts by Category of Cuts.[a]

Category of Cut	Store A	Store B	Store C	Store D	Total
	Dollars per Pound				
I	0.28	0.46	0.61	0.32	0.55
II	0.22	0.28	0.46	0.22	0.35
III	0.26	0.26	0.40	0.20	0.32
IV	0.11	0.09	0.20	0.10	0.16

[a] The categories of cuts were broken down according to price per pound of each cut. Price ranges and cuts in each category are given in Appendix Table 1.

Store D, being older, lacked the more modern and efficient facilities and equipment of the other sample stores. This resulted in greater sanitation problems in the meat department. Because separate facilities were not available, the meat was cut and wrapped in the same room. Also, no compartment, except the cooler, was available to keep the meat prior to wrapping. The cutting and wrapping area was kept at temperatures ranging from 63°F to 70°F, well above the 55°F recommended for an area of this type. To compensate for the less than optimum conditions existing in other areas of the operation, the display case was kept at a colder than optimum temperature, ranging from 22°F on the empty rack to 25°F to 28°F on the loaded rack. This extraordinary low temperature resulted in more than average freezing of packages, especially in the back of the case.

Store D, because of lack of storage for packaged meats, put more packages in the display case at one time than did any of the others in the sample. Steaks and ground meat were often stacked six high, roasts three high. The high density of packages in the case caused increased handling by the customers searching for a particular package. Also, the packages on the top of the stack were not as well cooled as some lower in the stack. All of the above conditions contributed to the greater than normal amount of deterioration and subsequent "pull-backs".

Store C, the highest volume store in the sample, had the next highest percentage of "pull-backs" at 2.35 percent (Table 1). The average daily "pull-backs" amounted to 22.5 pounds out of an average of 1,096 pounds of product processed each day. The percentage loss due to markdowns in terms of dollar sales, was the highest in the sample. The difference between the regular selling price of the "pull-backs", and the marked-down price, reduced the value by an average of $7.60 per day or 9.6 percent of the value of product processed.

Store C had facilities for separating the cutting and wrapping operations and also had a compartment for storing the cut-up meat until it could be wrapped. The cutting room remained from 45°F to 51°F, depending on the weather. The pre-wrap storage well was normally within the range of 34°F to 38°F. Temperatures in the display case ranged from 36°F to 37°F while loaded two to three packages high. No readings were taken directly on the empty rack. The display case had no storage space in it but a "reach-in" type of display case had been modified to provide storage for the packaged meat.

The relatively high percentage of "pull-backs" for Store C were partially a function of the attitude the meat manager had toward working his meat case. The meat manager for Store C tended to pull packages that were marginal in appearance and to mark them down more readily than other managers. Also, Store C tended to reduce prices more per pound for the various cuts (Table 2) than any of the other sample stores. Since it seems that all of the stores moved their old or deteriorated meat equally well, Store C may have been discounting its "pull-backs" excessively.

The physical aspects of the meat department in Store C were on or above par with the other stores, with the exception of the age of the store and the refrigeration system. Although the refrigeration system seemed to be slightly less effective than for Stores A and B, it did not show enough difference in the display case, cutting room, or storage facilities to warrant the relatively large percentage of "pull-backs" as compared to those stores. The sanitation in this meat department equaled or exceeded the other stores. The stocking policy was the same as for Stores A and B with packages maintained generally two and not more than three deep.

Store A had 2.1 percent "pull-backs" or an average of 9.6 pounds per day (Table 1). The estimated reduction in value was $1.62 per day or 0.36 percent of the value of product sold within the store. Store A had excellent refrigeration of all the areas in which meat was processed or stored. The cutting room temperature ranged from 53°F to 57°F. The meat was cut, placed on foam trays, and passed into a refrigerated well to await wrapping. The storage well ranged from 34°F to 37°F. The display case ranged from 25°F on the empty rack to from 34°F to 36°F with the rack loaded two to three high. There was storage space for packaged meat beneath the case.

Volume from this store during the sampling period was relatively low. The low volume may be partly attributed to a breakdown of the weighing and stamping equipment and an injury to the regular wrapper causing a slowdown in the processing of the meat for various lengths of time. This made it difficult to keep the display case loaded to its optimum level part of this time. The lack of variety and selection may have hurt the meat sales during the sample period.

Due to Store A's low volume turnover it could have been expected to have a higher "pull-back" rate than the higher volume stores, but because of its excellent facilities, especially the refrigeration system, the "pull-back" rate was one of the lowest. Additionally, the pull-backs in Store A were marked down at a lower rate per pound (Table 2) than Stores B and C but at a similar level to Store D.

Store B had the lowest "pull-back" rate of any store in the sample (Table 1). The losses from discounting amounted to only 0.15 percent of the value of sales. This store had nearly identical facilities to Store A. The cutting room temperature ranged from 55°F to 62°F. The temperature of the pre-wrap storage well ranged from 34°F to 38°F. The display case had a temperature range of 32°F on the bare rack to 37°F on the loaded rack. The display case also had storage space in it. The stocking policy was similar to Stores A and C. The case was seldom stacked more than two high and the packages taken by customers were replaced as needed. Since there was no discernable advantage of Store B over Store A in the physical factors considered, the very low "pull-back" was attributed to differences in the store operation. From observation, it appeared that

Store B did not pull packages of similar appearance as soon as Stores A and C. The meat pulled back by Store B was discounted at a higher rate per pound than in Stores A and D as far as the more expensive cuts were concerned (Table 2). Discounts were higher than D and about the same as A for the medium-priced cuts. Store B had the lowest per pound discount for the cheapest cuts.

Average daily "pull-backs" for the four sample stores totaled 55.2 pounds or 1.77 percent of the 3,119 pounds of product sold. The total value of discounts averaged $13.56 per day or 0.43 percent of the total value of the product processed. Over a year's time, these results project to 19,872 pounds of "pull-backs" or $4,882 loss due to discounted products.

Summary of Losses from Various Sources

The estimated average losses per store per year from shrinkage of primals and deterioration in retail cuts were:

Shrinkage	$2,800
Handling "pull-backs"	457
Loss due to discounts	1,220
Total	$4,477

Based on an average of 800 pounds of meat per store per day and assuming 360 sale days per year, the volume would be 288,000 pounds or nearly $285,000 in sales.1/ The total losses due to shrinkage and deterioration (not including losses in trim) amounted to 1.57 percent of the value of annual beef sales per market. The loss would therefore amount to 1.7 cents per pound of retail sales, or approximately $7.30 per carcass. While not large, it is a significant amount in terms of profit margins either at the store or producer levels, and would, of course, be greater at higher beef price levels.

Technical Investigations

Two investigations were conducted to try to determine more specifically some of the factors contributing to meat keeping quality and deterioration through shrinkage as observed in the stores sampled above.

Investigation I

Adjacent top round steaks were selected from each of four stores on two occasions from a fresh beef supply. All four stores were owned by the same food chain; however, two of these stores merchandized "choice" graded beef and two sold "good" graded beef.2/

The carcasses from which the steaks were cut were selected at random. As soon as the steaks were cut, one-half of them were placed in shallow display trays (Western foam tray, 2-S) and the remainder in deep display trays (Western foam tray, 4-D). Cuts in both types of trays were overwrapped with a resinite film (Bordens, RMF-61). An equal number of steaks were displayed in each store's self-service case and an equal number were stored in a home type refrigerator for 0, 3 or 6 days.

The total number of mesophiles and psychrophiles on the steaks were determined for each sample period. Mesophiles were incubated at room temperature for three days and the psychrophiles were incubated for seven days at 38°F. Lipid content was determined by chloroform-methanol extraction. Appendix Table 2 compares the data collected at each of the four stores. Percent lipid in the steaks from the stores selling choice beef was significantly higher than for the other stores, whereas percent moisture in the steaks was lower. However, the number of microorganisms per unit of surface area of the steaks was lower ($P < .05$) for the cuts from stores 1 and 2 (selling good beef).

One of the objectives of this investigation was to determine if there was any difference in the microorganism development on steaks depending upon whether they were stored in a self-service case or a modern home refrigerator. Data presented in Appendix Table 3, show no difference ($P > .05$) due to location when compared by display trays. However in making comparisons by days of storage, steaks stored in a home-type refrigerator possessed more ($P < .05$) microorganisms per unit of surface area after three days than steaks displayed in a self-service case.

A comparison of steaks displayed in shallow versus deep trays (Appendix Table 4) revealed no significant differences in percent lipid, moisture and number of microorganisms when compared within locations and days. There was no statistically significant evidence that the depth of tray affected microorganism count although there appeared to be a tendency for higher counts in deep trays. The steaks in deep trays lost their bloom much more rapidly than those in the shallow trays and were generally very unacceptable after three days of display.

Several unexplainable observations were noted for the lipid content of the steaks when comparisons were made by days of display within trays (Appendix Table 5). Significantly less ($P < .05$) lipid was found in the steaks displayed in shallow trays for six days than for either 0 or 3 days; this was not

1/ The average value of sales per day for the four stores was $3,164 (from Table 1) or $791 per store. The total value per year was $284,760, based on 360 sale days.

2/ Not all stores are identical to those involved in the Economic study which included only one store regularly selling "good" graded beef.

true for steaks in the deep trays. Steaks stored for three days possessed more ($P < .05$) lipid than the other two sample days. As expected, the number of microorganisms significantly increased as days of display increased. Most of the statistically significant changes occurred from day 3 to day 6.

Investigation II

In this investigation, beef ribs with trace, small, moderate or abundant marbling scores were selected. A total of 64 beef ribs were used with 16 being selected at four different times with an equal number of ribs per marbling score. Rib selections were made from beef carcasses within the A- maturity group, at the Swift Plant, Tolleson, Arizona. Therefore, the marbling scores represented the following grades; traces - low good, small - low choice, moderate - high choice, abundant - prime.

The ribs were removed from the carcasses, shipped to a distribution center in Tucson, and held in storage for seven days. On day seven, the ribs were cut into one inch thick steaks. The steaks were wrapped in shallow trays and placed in display cases with 12 hours of light and 12 hours of darkness. Random steaks within each marbling score were selected to be sampled at day 0, 3 or 6. Steaks from the first 32 ribs (Experiment 1) were maintained at 32°F in the display cases. For the second 32 ribs (Experiment 2), the temperature of the cases was set at 38°F.

Total intramuscular lipid, mesophiles and psychrophiles were determined as in Investigation I. Free moisture was determined by an ultracentrifugation technique by spinning muscle samples at 30,000 rpm for 45 minutes. Shrinkage of the steaks was calculated on the basis of weight loss from day 0 to either day 3 or day 6. The primary objectives of this experiment were to determine what influence the amount of intramuscular lipid (marbling) and the temperature of the display case might have on the microorganism growth on steaks.

The mesophile and psychrophile bacteria count listed in Appendix Table 6 strongly indicates that the relationship between the two types of organisms is quite high. Furthermore, in comparing these data by marbling score, it appears that degree of marbling had very little influence on the microorganism load of steaks displayed for various times.

As expected, the influence of time was very evident with regard to microorganism colony development (Appendix Table 7). There was a pronounced increase from day 3 to day 6. Further, it was apparent that the free moisture content of the steaks definitely decreased with time of display.

Comparison of the mesophile and psychophile data from Experiment 1 for display at 32°F with Experiment 2 at 38°F shows the dramatic effect of case temperature on displayed meat (Appendix Table 7). The microorganism increase was similar for both temperatures from day 0 to day 3, but from day 3 to day 6, the increase in microorganism per unit of steak surface area was 550 times greater for the 38°F stored steaks than for steaks displayed at 32°F.

SUMMARY AND RECOMMENDATIONS

Factors Contributing to Losses in Handling Beef at the Retail Level

The observations made in the four stores relative to beef handling practices and from the experiments conducted indicate a number of factors contribute to increased shrinkage and deterioration in quality of the product and to associated losses. Some of the major factors noted are as follows:

1. The longer the period primals and subprimals are stored in the cooler prior to cutting the greater the amount of shrinkage, but the rate of loss tends to decline after the second or third day.
2. The higher the temperatures in the cooler the greater the shrinkage losses.
3. Higher case temperatures result in significant increases in microorganism growth after the third day in the case and the appearance of the product deteriorates more quickly.
4. Microorganism growth increases with time in the display case. The rate of growth increased significantly after the third day.
5. The bloom disappears more quickly from steaks in deep rather than shallow display trays and there appears to be a tendency for higher microorganism growth in deep trays.
6. Shrinkage of individual steaks was influenced more by time of display than by temperature of the display case.
7. The degree of marbling had no significant influence on microorganism growth for displayed cuts of beef.
8. Stocking policy, volume of turnover and management policy on withdrawal and pricing of deteriorated cuts of beef affect the losses sustained.

Recommendations

Based on the observations made in this study and supported by other researchers' findings, a number of suggestions for improving operations in retailing beef are made below:

1. Temperatures in the Display Case, Cutting Room and Work Areas: Adherence to optimum temperature in the display case can result in added shelf life, improved quality and increased operating efficiency at the retail level. Meat displayed at an air temperature of 30°F has more desirable color retention, less weight loss, and lower bacteria count than meat displayed at 38°F [5]. A temperature of 30°F over and around the meat product is considered ideal but most meat cases typically are around 34°F. Other factors influencing the temperature in the display case (but not included in this investigation) are radiant heat from display lights and from ceiling surfaces [4].

   Temperatures of other work areas may also affect the deterioration of meat and the resulting "pull-backs". The temperature of the room in which the meat is processed into retail cuts should be cool enough to keep bacterial growth down and still be comfortable enough to work in. A temperature of 55°F is considered to be a compromise between the temperature considered good for meat and that desirable for the employees. It is not sufficiently low for the storage of meat. For this reason, meat being processed in the cutting room should be held in that room only long enough for the cutting operation, packaged as soon as possible, and then displayed at a lower temperature. The meat cutting room may have adjacent to it a compartment for storage of the cut-up meat prior to wrapping. This compartment should be kept at 34° to 36°F. Should cutting and wrapping occur in the same room, the temperature should be 55°F [1].

2. Wrapping Procedures: The material used should restrict air getting to the surface of the meat as much as possible and yet allow visual inspection of the package. One report [4] suggests the tighter wrap reduces the "hot house" effect associated with leaving an air space. The air space apparently tends to raise the surface temperature of the meat creating an ideal environment for the microorganisms that cause meat to darken and deteriorate.

3. Stocking Policy: Stocking policy affects "pull-back" in several different ways. An optimum volume of meat will maximize sales and minimize loss. Overstocking will offer a greater selection to choose from, but invites more handling of the packages while searching for the desired weight and appearance of the particular cut. Also, overstocking tends to restrict air flow over the packages and requires additional refrigeration to keep all the packages at the proper temperature or, failing that, invites increased deterioration from not having a proper temperature in the display case.

4. Shrinkage and Trim: Study should be made of potential savings from covering carcasses and primal cuts to reduce shrinkage and trim losses.

5. Alternative Procedures: While this study did not specifically research alternative systems, other studies and some test experiences indicate that systems of centralized processing and packaging may provide economies far in excess of any minor modifications made in traditional handling of beef [3]. A number of advantages have been suggested as possible from a centralized system. It would provide the potential for more flexibility in supplying stores with the types of cuts that sell best in the area. Reduced locations for cutting should improve the control over sanitation and other aspects of handling affecting product quality. More specialized activities should reduce labor needs and permit store employees to concentrate on customer service. Less investment in equipment, building space, etc., should be required with the specialized system. Some reduction in transport costs and improved use of waste or trim should be expected. Further research is needed to determine the precise effects, costs and savings to be expected from various systems of centralized cutting and handling.

APPENDIX

TABLE 1. PRICES FOR RETAIL BEEF CUTS.

Category	Price Per Pound	Cuts
I	$2.00	Tenderloin Rib Eye Steak New York Cut
II	$1.50-2.00	Breakfast Steak Top Sirloin Loin Tip Eye of Round Steak Eye of Round Roast Porterhouse Steak
III	$1.00-1.50	Chopped Sirloin Diet Ground Beef Sirloin Steak Top Round Rib Steak Rump Roast Diet Oven Roast Sirloin Tip T-Bone Steak Boneless Round Cube Steak Diet Steak London Broil
IV	$1.00	Ground Beef Ground Chuck Ground Round Chuck Steak T-Bone Roast Cross-rib Roast Boneless Chuck Arm Swiss Arm Chuck Rib Roast Short Ribs Round Steak Stew Meat

Source: Prices are based on a composite of prices observed for various cuts at the time of the survey, in the autumn, 1971.

TABLE 2. COMPARISON OF STORES FOR THE VARIOUS DATA COLLECTED FROM EACH STEAK.

	Store[a/]			
Parameter	1	2	3	4
Lipid, percent	12.6[c/]	12.5[c/]	16.2[d/]	13.9[c/]
Moisture, percent	72.6[c/]	72.4[c/]	71.4[d/]	71.5[d/]
Microorganisms[b/]	2.8[c/]	2.9[c/]	3.2[d/]	3.3[d/]

[a/] Store 1 and 2 sell USDA good graded beef, whereas 3 and 4 sell USDA choice.

[b/] Log of the number of microorganisms per $2.5 cm^2$ of steak surface area.

[c,d/] Those mean values with different superscripts are significantly different ($P < .05$)

TABLE 3. LEAST SQUARES MEANS FOR LOCATIONS NESTED WITHIN TRAYS AND DAYS.

Parameter	Shallow Tray		Deep Tray		Day 0		Day 3		Day 6	
	Loc. 1[a]	Loc. 2	Loc. 1	Loc. 2	Loc. 1	Loc. 2	Loc. 1	Loc. 2	Loc. 1	Loc. 2
Lipid, percent	13.8	13.6	13.7	14.1	13.5	13.5	14.8	14.6	12.9	13.5
Moisture, percent	72.2	72.1	72.0	71.8	72.5	72.5	71.9	71.9	71.9	71.4
Microorganisms[b]	3.2	3.1	3.4	3.1	3.3	2.5	4.3[c]	2.7[d]	5.5[c]	5.1[d]

[a] Location 1 - home refrigerator and Location 2 - store self-service case.

[b] Log of the number of microorganisms per 2.5 cm^2 of steak surface area.

[c, d] Those mean values within each major heading with different superscripts are significantly different ($P < .05$).

TABLE 4. LEAST SQUARES MEANS FOR TRAYS NESTED WITHIN LOCATIONS AND DAYS.

Parameter	Location 1		Location 2		Day 0		Day 3		Day 6	
	Shallow Tray	Deep Tray	Shallow Tray	Deep Tray	Shallow Tray	Deep Tray	Shallow Tray	Deep Tray	Shallow Tray	Deep Tray
Lipid, percent	13.9	14.1	13.2	14.0	14.7[b]	12.3[c]	14.0	15.4	12.3	14.1
Moisture, percent	72.1	71.8	72.2	71.9	72.3	72.6	72.1	71.7	71.9	71.3
Microorganisms[a]	3.2	3.4	3.1	3.1	2.2	2.1	2.7	2.8	4.4	4.9

[a] Log of the number of microorganisms per 2.5 cm^2 of steak surface area.

[b, c] Those mean values within each major heading with different superscripts are significantly different ($P < .05$).

TABLE 5. LEAST SQUARES MEANS FOR DAYS NESTED WITHIN LOCATIONS AND TRAYS.

Parameter	Location 1			Location 2			Shallow Tray			Deep Tray		
	Day 0	Day 3	Day 6	Day 0	Day 3	Day 6	Day 0	Day 3	Day 6	Day 0	Day 3	Day 6
Lipid, percent	13.5	14.8	12.9	13.5	14.6	13.5	14.7[b]	14.0[b]	12.3[c]	12.3[b]	15.4[c]	14.1[b]
Moisture, percent	72.5[b]	71.9[c]	71.9[b]	72.5[b]	71.9[c]	71.4[b,c]	72.3	72.1	72.0	72.6[b]	71.7[c]	71.3[c]
Microorganisms[a]	2.2[b]	2.9[c]	4.7[d]	2.2[b]	2.5[c]	4.6[d]	2.2[b]	2.7[b]	4.4[c]	2.1[b]	2.8[c]	4.9[d]

[a] Log of the number of microorganisms per 2.5 cm^2 of steak surface area.

[b,c,d] Those mean values within each major heading with different superscripts are significantly different ($P < .05$).

TABLE 6. LEAST SQUARES MEANS FOR PERCENT MOISTURE, LIPID, SHRINK, AND TOTAL MICROORGANISMS BY MARBLING SCORE.

Parameter	Experiment I[a]			
	Abundant	Moderate	Small	Trace
Lipid, percent	37.1[b]	21.2[c]	15.3[d]	11.6[e]
Moisture, percent	65.8[b]	70.5[c]	72.3[d]	73.0[e]
Free Moisture, percent	26.2	27.7	27.3	27.1
Shrink, percent	0.8	0.8	0.8	0.8
Mesophiles[f]	5.8	5.6	5.4	5.4
Psychrophiles[f]	5.8	5.6	5.3	5.2

Parameter	Experiment II[a]			
	Abundant	Moderate	Small	Trace
Lipid, percent	31.0[b]	22.2[c]	17.2[d]	11.9[c]
Moisture, percent	68.1[b]	70.6[c]	72.4[d]	73.0[d]
Free Moisture, percent	23.9[b]	25.1[c]	26.3[d]	26.5[d]
Shrink, percent	0.8	0.8	0.9	0.9
Mesophiles[f]	5.0	5.5	5.4	5.3
Psychrophiles[f]	5.0	5.4	5.3	5.1

[a] Display temperature for Experiment I was 32°F and for Experiment II 38°F.

[b,c,d,e] Values within a line with different superscripts are significantly different ($P < .05$).

[f] Log of the number of microorganisms per 1 cm^2 of steak surface area.

TABLE 7. LEAST SQUARES MEANS FOR MOISTURE, LIPID, AND SHRINK AND TOTAL MICROORGANISMS BY DAYS.

	Experiment I				Experiment II		
Parameter	Day 0	Day 3	Day 6	Parameter	Day 0	Day 3	Day 6
Lipid, percent	19.8[b/]	22.1[c/]	22.0[c/]	Lipid, percent	20.4	21.6	19.8
Moisture, percent	71.2[b/]	70.0[c/]	70.0[c/]	Moisture, percent	71.4	70.6	71.0
Free Moisture, percent	29.5[b/]	25.9[c/]	25.8[c/]	Free Moisture, percent	28.1[b/]	24.3[c/]	24.0[c/]
Shrink, percent	0.0[b/]	1.0[c/]	1.3[d/]	Shrink, percent	0.0[b/]	1.1[c/]	1.4[d/]
Mesophiles[e/]	5.3[b/]	5.8[c/]	8.0[d/]	Mesophiles[e/]	4.0[b/]	4.9[c/]	8.5[d/]
Psychrophiles[e/]	4.9[b/]	5.9[c/]	7.7[d/]	Psychrophiles[e/]	4.0[b/]	4.6[c/]	8.5[d/]

[a/]Display temperature for Experiment I was 32°F and for Experiment II 38°F.

[b,c,d/]Values within a line with different superscripts are significantly different ($P < .05$).

[e/]Log of the number of microorganisms per 1 cm^2 of steak surface area.

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