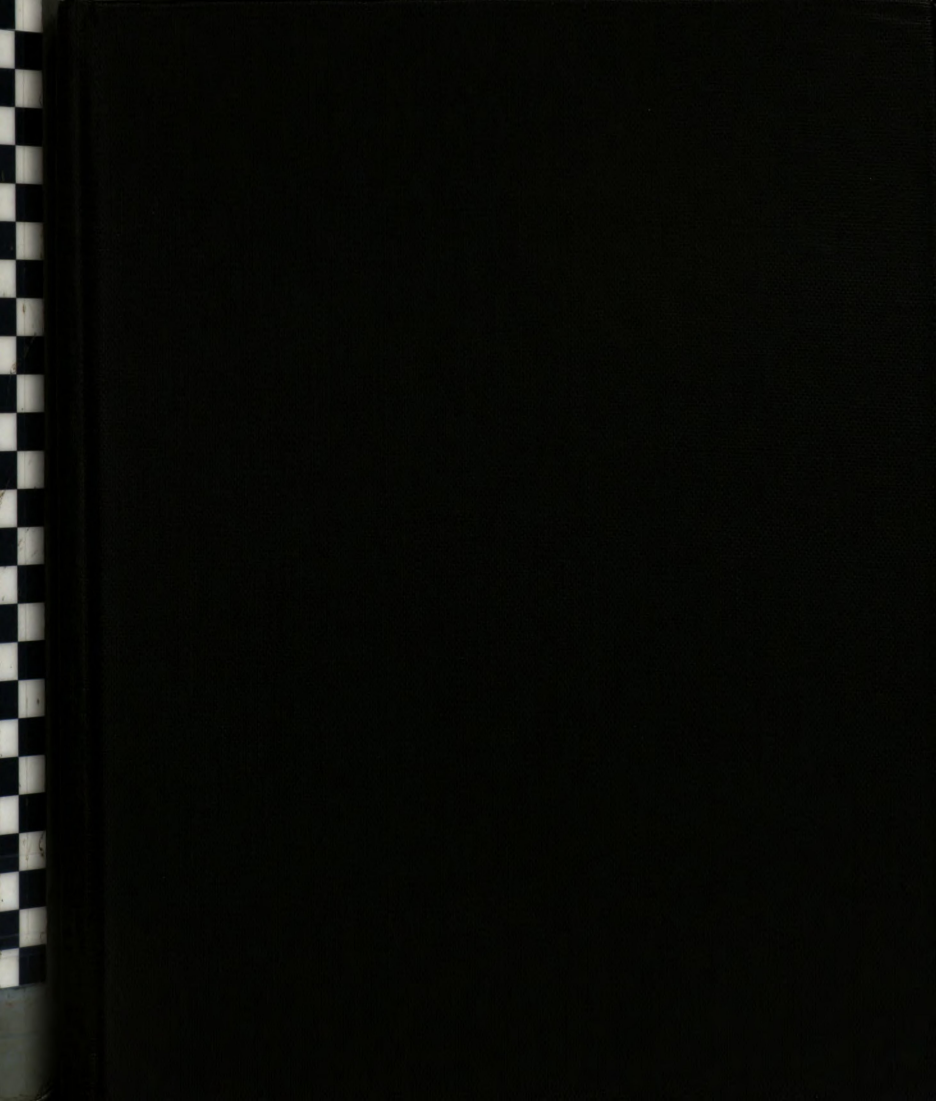






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THE APPLICATION OF QUALITY
ASSURANCE PRINCIPLES TO A
COMMISSARY FOODSERVICE
SYSTEM

presented by

RONALD FRANCIS CICHY

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of the requirements for

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THE APPLICATION OF QUALITY
ASSURANCE PRINCIPLES TO A
COMMISSARY FOODSERVICE
SYSTEM

By

Ronald Francis Cichy

A DISSERTATION

Submitted to
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in partial fulfillment of the requirements
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1981

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ABSTRACT

THE APPLICATION OF QUALITY ASSURANCE PRINCIPLES TO A COMMISSARY FOODSERVICE SYSTEM

By

Ronald Francis Cichy

The thrust of this research was an analytical and comprehensive investigation of ground beef patty production in a commissary foodservice system. Several quality assurance/quality control (QA/QC) tools were used to evaluate the effectiveness of this firm's total quality system. The Hazard Analysis Critical Control Point (HACCP) procedure revealed deficiencies in the system and pointed the way toward corrective action. The costs of quality and the management responsibilities regarding QA/QC were discussed in a general sense. The Pareto analysis focused QA/QC efforts on the "vital few" sensitive locations in the commissary meat production room.

The ground beef patty weights were analyzed to determine uniformity. A process capability study and analysis revealed the extent to which the patty weights conform to the corporation's established tolerances. Recommendations were developed based on the information resulting from the

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ground beef patty weight investigations.

Microbiological analyses of both incoming beef and finished ground beef patties determined the extent of product contamination. Recommendations to reduce the contamination and monitor the product's bacterial load were presented. The ground beef patty nutrient profile was studied to ascertain its contribution to daily nutritional needs. Commissary sensory evaluations were evaluated and recommendations were made regarding the use of sensory taste panels and sensory analysis in both the commissary and restaurants.

Suggestions were developed in regard to product recall procedures. Guidelines for initiating a system for product traceability in both the commissary and restaurants were discussed. The topic of quality audits was covered in relation to comprehensive and special quality surveys. A system for classifying and handling customer complaints was developed.

The objective of this research was to provide the management of this commissary foodservice system with an independent study of their quality program. Several of these recommendations can be adapted to any foodservice system, regardless of size. The recommendations presented allow the management group to be proactive rather than reactive.

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The study illustrated that the QA/QC system must have the support of management, if it is to be effective. QA/QC in a foodservice firm should result in the satisfaction of the target market's needs coupled with a profitable bottom line.

To my wife,

Susan E. Moeller

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CHAPTER 1

INTRODUCTION

Any foodservice operation can be regarded as a system of interrelated activities designed to deliver a series of products to the point at which they are available for consumption by the target market. The target market has definable needs that must be satisfied by the foodservice operation if the organization is to remain viable and realize a profit. The objective of any foodservice management group is to define these needs and meet or exceed the clientele's expectations.

1.1 Objective

The objective of this research was to apply quality assurance and quality control principles, especially the Hazard Analysis Critical Control Point (HACCP) concept, to a commissary foodservice system and to discover whether the quality assurance/quality control principles will enable management to define and meet their target market's expectations. The focus of this research is limited to a comprehensive treatment of one product produced in this commissary foodservice system. The product chosen was a double-deck hamburger sandwich. This product is the highest volume ground beef menu item produced by the commissary foodservice system and is subject to all the possible abuses of any

foodservice system. The commissary's annual production of this product is in excess of 800 tons.

1.2 Quality Assurance Tools Used

The focus of this research was centered on a critical analysis of the commissary foodservice system as it presently exists. The HACCP concept was used as a template to reveal existing and potential problems in this system. HACCP principles were tested in the system to determine if this concept could be used as a preventive management tool in the quality assurance program for this operation. Should the application prove useful for ground beef, application to other items will naturally suggest itself.

Several other quality assurance tools were also applied to the commissary foodservice system. These tools permit the quality assurance practitioner to make decisions on whether or not the product complies with the operation's quality standards. In addition to the HACCP investigation, a process capability study of individual patty weights was performed to determine the degree of variability of these weights. A Pareto analysis revealed which critical locations to monitor in relation to swab tests used to determine total plate counts during the pre-operation inspection of the commissary. Specified sampling acceptance procedures were developed to maintain acceptable quality protection based on both organizational and governmental standards. The topic of quality audits was investigated as a tool to aid management in the periodic evaluation of the system.

The concept of product traceability was the underlying common thread that permeated all aspects of the system analysis. Where appropriate, recommendations were developed as a result of the research to aid the management and staff of the commissary foodservice system in their task of monitoring the quality of the product. Several of these recommendations can be adapted to any type of foodservice operation, regardless of size. The emphasis placed on each of these recommendations will vary, based on management evaluation of the specific needs of its target market.

1.3 Quality Assurance Tools Not Used

Several other quality assurance tools were not used to analyze the commissary foodservice system because they are beyond the scope of this study. However, these quality assurance tools are addressed in Chapter 5, Discussion and Recommendations. These quality assurance tools include the costs of quality, product recall procedures, special quality surveys and comprehensive quality audits.

CHAPTER 2

REVIEW OF LITERATURE

The foodservice industry in the United States is characterized by its rapidly changing and dynamic nature. The emergence of a customer-dominated economy is one manifestation of the shift from an industrial society to one based on service. No industry has more to gain from fulfilling the wants and needs of the customer than does the foodservice industry.

2.1 Foodservice Industry Statistics

The National Restaurant Association (NRA) is projecting a moderate recovery in 1981 from the slump that has affected the foodservice industry for the last two years. The NRA, in its annual Foodservice Industry Forecast, predicts that total industry sales in 1981 will reach \$122.7 billion, a gain of 10.2 percent (Anonymous, 1981). Factoring out menu price increases, the NRA forecasts the first industry real growth rate in two years, up 0.3 percent. NRA arrives at this real growth rate on the assumption that menu prices will rise approximately 10 percent in 1981.

The NRA's 1980-1981 president, William Regas, commented that 40 percent of all money spent on food is spent in foodservice facilities. Within ten years, that figure is

projected to rise to 50 percent of each food dollar (Anonymout, 1980b). Of the 43 billion meals eaten outside the home annually, 24 billion are served in restaurants and other commercial operations, while 19 billion are eaten in schools, colleges, employee dining rooms, hospitals, and other institutions. Walter Conti, NRA's vice-president, points out that today's consumers are more demanding--they want quality food at reasonable prices, good service in clean surroundings, and variety in a pleasing atmosphere (Anonymous, 1980b).

According to the National Restaurant Association's 1977 consumer attitude survey entitled "Consumer Reactions toward Restaurant Practices/Responsibilities," food quality/preparation was ranked the number one factor influencing the customer's choice of full-service restaurants (Anonymous, 1979b). In the same survey, customers of both quick- and moderate-service operations ranked food quality/preparation as the second most important characteristic in choosing a restaurant operation. The top-ranking characteristic in both quick- and moderate-service foodservice facilities was restaurant cleanliness.

2.2 Definitions of Quality

What constitutes quality in foodservice operations? Although varying with the nature of the operation, almost every component of the dining-out experience, including menu variety, prompt service, food preparation techniques, and ambience is an indicator of quality. To provide quality, the

restaurateur must establish standards for personnel, equipment, sanitation, raw materials, food preparation, presentation, and service (Minor, 1977). The customer's perceived value is based on quality and price and is also affected by other factors (Kotschevar, 1975). Gould (1977) stated that quality makes a product what it is. The term "quality," without being carefully defined in relation to some standard, means either very little or too much.

The average consumer associates quality with subjective personal preferences, as something that is liked or disliked, excellent, superior, great, or good (Thorner and Manning, 1976). Quality, from a technical or scientific viewpoint, can be defined as an orderly classification of the chemical and physical characteristics of a product. Flavor, texture, appearance, consistency, palatability, nutritional values, safety, ease of handling, convenience, storage stability, and packaging are the essential elements that must be evaluated in establishing product quality. Management equates quality with certain economic factors, such as the cost of the product, profits generated and consumer acceptance within the intended selling price range (Thorner and Manning, 1976).

Quality of foods may be defined as the composite of the characteristics that differentiate individual units of a product (Kramer and Twigg, 1962). These characteristics influence the degree of acceptability of the unit by the buyer. Quality may mean excellence in relation to

certain things that a consumer wants in a particular product (Grant and Leavenworth, 1972). Paul and Palmer (1972) observed that food quality is evaluated by sensory, chemical, and physical methods. Two dominant factors emerge in the definition and evaluation of quality: the actual physical or chemical measurement of the product, and the acceptance of the product by the consumers based on whether or not it completely satisfies their "wants." The development of a quality product and organizational image, coupled with a consistent marketing effort, can enhance a firm's market share (Tiegs, 1980).

Quality is never the result of the efforts of the quality control or quality assurance department alone. Rather, quality is the one factor that the entire organization must address and support. It is a valued organizational goal and outcome. Darrah (1974) stated that it is management's responsibility to establish quality as an attitude that permeates the entire organization. The development of quality judgment in employees is highly significant to satisfactory production (Terrell, 1979). Quality in production refers to the taste, appearance, texture, nutritional value, and level of excellence of the food served (Mizer and Porter, 1978). Clear concepts of quality are best developed through firsthand experience (Terrell, 1979).

2.21 Quality Control

Quality control may be defined as the maintenance of quality at levels and tolerances acceptable to the buyer

while minimizing costs for the supplier (Kramer and Twigg, 1962). Quality control evaluates and applies desired standards to products; it is concerned primarily with things rather than people (Laughlin, 1961). Quality control has been defined as assuring day-in, day-out consistency of quality in each product offered for service (Mizer and Porter, 1978). The standards of quality in a foodservice operation's production department may be established by management, but the achievement of established standards is largely in the hands of the cook and others. Mizer and Porter (1978) pointed out that the task is complicated by the very nature of quality, since it is difficult to keep personal opinion out of quality judgments.

Quality control has been defined as the operational techniques and activities that sustain a quality of product or service that will satisfy given needs; also the use of such techniques and activities (ANSI/ASQC Standard, 1978). Without a quality control program, an organization cannot serve a consistent standard. A good quality standard should cover essential characteristics that indicate quality in a product (Kotschevar, 1966). Reece (1979) observed that the modern-day concept of "total quality control" involves sensory evaluation in all stages of product flow, from inspection of incoming raw materials through surveillance of the finished products. It is now recognized by most companies that quality controls are vital and, in many instances, represent the very life blood necessary to

compete successfully in today's competitive and changing markets (Bianco, 1977). On the other hand, some companies still view quality control programs as an expense with no direct profit to the firm (Herrmann and Herrmann, 1978).

2.22 Quality Assurance

Quality assurance includes all the planned systematic actions necessary to provide adequate confidence that a product or service will satisfy given needs (ANSI/ASQC Standard, 1978). The primary responsibility for the safety, wholesomeness, and nutritional quality of food rests with the food processor, not the Food and Drug Administration or any other governmental organization. The consumer's best hope for safety and quality in food lies in the development and maintenance of adequate quality assurance programs (Angelotti, 1975). Quality assurance systems must be installed in a company's operation to provide some degree of assurance that the products manufactured and shipped are not adulterated or misbranded. The quality assurance system must include ingredient inspection and control, manufacturing control, and distribution control (Smith and Smith, 1975). An effective quality assurance program should embrace all available means of testing, and sensory evaluation is one of the most important (Reece, 1979).

Lushbough (1978) stated that quality assurance oversees and evaluates production. There can be no quality assurance program without specific defined procedures and operational techniques of quality control. Neither quality

control nor quality assurance, alone or together, can guarantee the production of a quality product. Commitment to consumers must involve every individual who works to produce and distribute appetizing and attractive foods.

Creation of an effective quality assurance program is indicative of a modern food company's commitment to providing consumers with safe, wholesome, and nutritious foods of consistent high quality at a reasonable and realistic price (Lushbough, 1978). Quality assurance must be held responsible for measuring, auditing, and reporting quality as an objective check and balance for management purposes (Briskey, 1978). Quality assurance is a complete system with written specifications and standards, checks of raw materials and other ingredients, inspection of critical control points in the process, and an audit of the system to monitor the end product (Wodicka, 1977).

The establishment of an effective quality assurance program in any food operation requires, in part, that the program be well defined, adequately communicated, and clearly understood by all participants and put into practice (Bolaffi et al., 1973). The program must standardize and clearly specify all formulae, manufacturing and storage conditions, product handling, processing, and finished goods inspection. The quality assurance effort must also involve on-going testing and monitoring of physical, chemical, sensory, and microbiological qualities. Assurance of quality in a foodservice operation must follow the same basic

principles that apply generally to food operations producing packaged products (Kubu, 1973). Restaurants, unlike commissary foodservice systems, are unique, however, in that products flow directly into the hands of the consumer, with minimal opportunities to accumulate output, sample, analyze, and withdraw unacceptable products. In contrast, a commissary foodservice system may provide increased opportunities for a dynamic quality assurance program, since food production and service areas are located in separate facilities.

2.3 Commissary Foodservice Systems

The development and proliferation of commissary foodservice systems has been made possible by technological developments of sophisticated foodservice equipment (Unklesbay et al., 1977). Foodservice organizations that adopt the commissary foodservice system aim to utilize resources more effectively by achieving economies of scale in food procurement and production. In a commissary foodservice system, the food procurement and production functions are centralized. The prepared menu items are then distributed to several remote areas for final preparation and service (Unklesbay et al., 1977).

Commissary operations usually purchase food products in larger volume with less frequent deliveries; therefore, the raw product cost is frequently less than that in conventional foodservice systems. Weisman (1979) observed that economies of scale in food purchasing provide the commissary foodservice organization with increased buying clout.

This system provides an additional advantage in that there is a corresponding reduction in purchasing time on the part of the unit or restaurant manager, leaving more time to concentrate on other management functions. Commissary systems procure food products that have received limited or no processing (Unklesbay et al., 1977). Expensive multi-function equipment often is required in the commissary for preparation of foods from the unprocessed state.

Commissaries enable the use of the specialization concept regarding employees, equipment, and the physical facility. This approach potentially increases the efficiency of food production due to the reduced duplication of production labor and equipment. An increased investment in both equipment and labor is necessary if production occurs at each foodservice site. The commissary foodservice system centralizes purchasing and production and, therefore, the overall total investment may be decreased. Due to economies of scale, more expensive and sophisticated production equipment can be utilized in a commissary foodservice system. Unklesbay et al. (1977) suggested that space requirements at the service sites are minimized, however, because only limited production equipment is required. Food production in a centralized facility can be more carefully monitored and has the potential for increased quality control, cost control, and less waste. The commissary kitchen helps restaurant groups insure product uniformity and reduced costs. This system also aids restaurant groups in

competing more effectively with large franchised operations (Anonymous, 1980a).

Since the food production and food service areas are located in separate facilities, the function of food distribution must receive considerable attention for the effective and efficient operation of a commissary foodservice system (Unklesbay et al., 1977). Distribution continues to be a major concern to the major foodservice chains (Weisman, 1979). There is a need to establish precise standards and a rigid monitoring of these standards within the operating system of each commissary (Cremer and Chipley, 1979).

A commissary foodservice system has been referred to as a commissariat, central commissary system, satellite system, and a food factory (Unklesbay et al., 1977). The term, "commissary," defines the location where food is procured, initially processed, and stored for shipment to the restaurants. Restaurants have also been called commercial foodservice operations, stores, retail outlets, and service sites. A conventional or traditional foodservice system, in contrast, is a single facility in which all of the basic operating activities from purchasing through service take place. In this thesis, a commissary foodservice system designates the commissary and the restaurants, while the term, "restaurant," identifies the location where the food is served to the customers.

The data for the study were obtained from a commissary foodservice system in the midwest, which reported a

foodservice sales volume in excess of \$125 million in 1980. The commissary annually ships over two million pounds of fresh beef and more than 1,500 tons of ground beef to well over 100 restaurants, all of which are low- to moderately priced full-menu table-service family restaurants. The ground beef product in this study accounts for over half of the total amount produced.

2.4 Ground Beef Consumption in the United States

In recent years, consumption of ground beef in the United States has increased rapidly. Predictions for 1980 estimate that over 14 billion pounds of ground beef, or over half of the total production of beef, will be consumed (Cross et al., 1980). The fresh meat industry is currently undergoing changes in processing, packaging, and distribution of raw ground beef. These changes are the result of the imposition of bacterial standards by some governmental agencies and the desire of meat processors to increase the shelf-life of raw meat products (Foster et al., 1977). To accomplish these goals, many retail food chains have centralized processing and distribution of fresh meat products, which has resulted in little or no meat processing at the retail level.

There is much concern by the general public about the microbial quality of ground meat (Pivnick et al., 1976). The process of manufacturing ground beef involves the grinding of cellular tissue. This process distributes bacteria normally present on the surface of the meat throughout the

entire product, thereby possibly creating an ideal condition for their multiplication (Duitschaever et al., 1973). A causal relationship exists between mishandling and the contamination of ground meat with microorganisms responsible for food poisoning (Karim, 1977). Ground beef may contain large numbers of bacteria at the point of sale (Duitschaever, 1977).

The bacteriological condition of ground beef is of concern to all segments of the foodservice industry. Reduced shelf-life, discoloration of the product, and economic losses as a result of bacteria are often encountered (Field et al., 1977). Fabrication of ground beef uses a large portion of the bovine carcass (Emswiler and Kotula, 1979). Frequently, ground beef contains a wide variety of microorganisms, some of which might result in food-associated infection or intoxication. However, if properly handled and cooked before consumption, these products should present few public health hazards (Foster et al., 1978).

2.5 Hazard Analysis Critical Control Point Concept

Quality of meals is a primary objective of foodservice systems; therefore, quality control is a major management function (Bobeng and David, 1977). The Hazard Analysis Critical Control Point (HACCP) concept is a preventive approach to quality control. The principles of HACCP, as applied to food systems, emphasize microbiological control and identify process stages where loss of control could present a food safety risk. A careful analysis of ingredients,

products, and processes is needed to determine the components or areas that must be maintained under very strict control to assure that the end product meets the established microbiological specifications (Bauman, 1974).

The HACCP concept was developed jointly by the Pillsbury Company, the U.S. Army Natick Laboratories, and the National Aeronautics and Space Administration. The objective of HACCP was to apply a zero-defects program to the production of food. The Food and Drug Administration's first use of HACCP was in the low-acid canned food industry, using the Good Manufacturing Practice (GMP) regulations for low-acid canned foods as a guide for the inspectors trained in the HACCP technique (Kauffman, 1974). Each food processor's own quality control system was used, when possible. If that was not possible, the FDA inspectors identified the critical points in the processing procedure. Ito (1974) suggested that questions need to be asked in order to identify the critical control points.

Hazard analysis is the identification of sensitive ingredients, critical process points, and relevant human factors as they affect product safety (Bauman, 1974). Critical control points are those process determiners that, under loss of control, would result in an unacceptable food safety risk (Bauman, 1974). Hazard analysis begins with the development of a process flow diagram that includes all relevant processing factors and details and is specific for the food, process, equipment, and plant involved (Peterson and

Gunnerson, 1974). Once each step in the processing, packaging, and distribution of the food product has been analyzed, critical control points can be established (Curtis and Huskey, 1974). The type of hazard and its critical control point may differ with each product, ingredient, package, processing procedure, and storage and handling technique.

Bauman (1974) stated that hazard analysis must consider the ingredients, the processing steps, and the potential for consumer abuse of the product. The HACCP procedure is a useful tool for preventing hazards by analyzing the hazards of raw materials, the hazards during processing, and the hazards of consumer abuse. Peterson and Gunnerson (1974) identified as the chief value of HACCP its ability to point out problem areas and problem situations in food processing. The feedback component of HACCP permits management to use this concept as a preventive approach to quality assurance. The value of HACCP to management is precisely what management makes of it.

HACCP models have been applied to both roast beef juice (jus) (Bryan and McKinley, 1980) and roast beef preparation (Bryan and McKinley, 1979) in foodservice establishments. Recommendations were developed for hot holding, cooling, storage, and reheating of these food products to minimize microbiological problems. HACCP models have also been adapted to the quality control of entree production in hospital foodservice systems (Bobeng and David, 1977). The entree chosen was the beef loaf, analyzed in three types

of foodservice systems (i.e., conventional, cook/chill, and cook/freeze). Four critical control points were identified for HACCP models for foodservice systems: ingredient control and storage, equipment sanitation, personnel sanitation, and the time-temperature relationship.

2.51 Ingredient Control and Storage

Ingredient control and storage includes the development of ingredient specifications that aid in providing sensory, quantitative, and microbiological control. Commercial foodservice operations term these guidelines standard purchase specifications. Standard purchase specifications are precise statements of qualities and other desired factors in merchandise (Kotschevar, 1975). They specify the quality and quantity of each item purchased by the operation. Standard purchase specifications are used to develop the standard receiving specifications, which facilitate verification of the quality and quantity of food items delivered by the foodservice operation's suppliers. Once food items are received, they should be stored promptly to prevent or control loss or waste from deterioration or infestation (West et al., 1977). Time-temperature considerations are very important during food storage, varying with the product and the storage area under consideration.

2.52 Equipment Sanitation

Equipment sanitation is a critical control point because inadequate cleaning of equipment and cross-contamination have been identified as two factors that

contribute to foodborne disease outbreaks (Bryan, 1978b). Inadequate cleaning of equipment can be corrected if foodservice operators are willing to develop cleaning schedules and specific procedures for cleaning each piece of equipment. Once developed, the proper cleaning methods should be communicated to workers in a planned step-by-step training program (Avery, 1980). The likelihood of cross-contamination can be minimized through the proper cleaning and sanitizing of all foodservice equipment and utensils after each changed use. The equipment and utensils frequently involved in cross-contamination include knives, cutting boards, food slicing machines, grinders, tables, pots, and pans.

2.53 Personnel Sanitation

Personnel sanitation is a critical control point because the human being is often the common link in foodborne disease outbreaks (Bryan, 1979). Foodservice personnel may contribute directly or indirectly to microbiological contamination (Bobeng and David, 1977). Managers and supervisors of foodservice employees have the responsibility for training their personnel in good foodhandling techniques, personal hygiene, proper cooking and storage methods, and general sanitation. Richardson (1974) stated that the incompetent employee can be responsible for any number of unsanitary conditions in a foodservice establishment that may lead to outbreaks of foodborne illness. It is management's mission to increase the level of employee competency

through well planned and implemented training programs designed specifically for foodservice personnel.

2.54 Time-Temperature Relationship

Time-temperature is a critical control point that must be monitored in all process flow stages. Improper supervision of correct time-temperature relationships has resulted in several outbreaks of foodborne illnesses (Bryan, 1979). The inadequate cooling of food was associated with most of the foodborne outbreaks, with bacterial foodborne disease, and frequently with outbreaks that originated from food prepared in foodservice establishments (Bryan, 1978a). Typically, inadequate cooling practices were either failing to refrigerate cooked foods or refrigerating foods in large stock pots or other large containers. Large, bulky masses of food cool very slowly. Other important factors related to time-temperature include a lapse of a day or more between preparation and service; inadequate thermal processing, canning, or cooking; inadequate reheating; and inadequate hot storage.

The time-temperature relationship is based on a temperature range identified as the temperature danger zone (Longree, 1972). This zone covers the range of 45°-140°F (7°-60°C) and takes into account the favorable multiplication temperatures of Staphylococcus, Salmonella, and fecal Streptococcus. The primary objective of food storage, preparation, holding, and reheating should be to minimize the amount of time food products are exposed to this

temperature danger zone. The internal product temperature during chilled food storage or holding should be less than 45°F (7°C), while the internal product temperature during heated food holding should be greater than 140°F (60°C). Establishing time-temperature standards is a practical method for monitoring entree production in foodservice systems (Bobeng and David, 1977).

2.55 Feedback characteristics of HACCP

The HACCP concept is a tool that can be used to identify and analyze an operation's deficiencies. As a management tool, HACCP works if it is used properly. It is like a template which, if placed on top of a system, can pinpoint deficiencies and potential problem areas within that system. The HACCP concept is not a panacea, but must be used as part of a comprehensive quality assurance program (Bianco, 1977). Feedback to management is an important aspect of HACCP, but that information is only meaningful if management uses it to their advantage. Quality audits are important components of a quality assurance program, providing information that allows management to "fine tune" the system.

2.6 Microbiological Aspects of Ground Beef

Meat and poultry, and food products they comprise, were identified as the vehicle in over half of the reported outbreaks of foodborne disease in the United States from 1968 to 1977 in which the vehicle was known (Bryan, 1980). Ground beef accounted for 8.8 percent of the number of meat and poultry products that were reported as foodborne vehicles

in outbreaks in the United States during the same ten-year period. One of the primary objectives of the cooking process is the thermal destruction of microorganisms (Crespo and Ockerman, 1977). The pathogens found in ground beef may either survive the cooking process or be introduced into the product after it has been cooked. Cooked hamburger patties are rather unlikely vehicles because they are usually thoroughly cooked and consumed shortly after cooking.

The primary health problem in ground beef appears to be associated with eating raw or rare ground beef that contains large numbers of surviving Salmonella. Inadequate cooking of ground beef menu items (e.g., meatballs, casseroles, and meat loaf) may explain the reason behind some of these reported outbreaks of salmonellosis. Other factors important in foodborne disease outbreaks associated with ground beef may be inadequate refrigeration of leftovers and cross-contamination.

Centralized processing of meats has been shown to be economically feasible, and the current trend is toward centralized processing in the meat industry (Shoup and Oblinger, 1976). Merchandising and distribution patterns for fresh meat products are undergoing changes in the meat packing and processing industries. Establishment of centralized fabrication and distribution plants has resulted in the mass production of fresh meat products in one location with little or no meat processed at the retail level (Berry and Ai-Ti Chen, 1976). In this system, meat products

are initially processed at a location some distance from the retail food outlet or restaurant where they are sold.

The centralized processing or commissary foodservice system may be a potentially hazardous design due to the numerous phases of product flow, multiple service locations, and time span or distance from the point of production to the point of ultimate service (Cremer and Chipley, 1977). On the other hand, products that are handled according to prescribed sanitary procedures can be in safe bacteriological condition at the point of service (Dahl, et al., 1978).

The processes of chopping and grinding enable bacteria present on the meat's surface to be distributed throughout the product. The ultimate bacterial quality and resulting shelf-life of ground beef depends on the bacterial level of the trimmings, sanitary conditions during processing, and time and temperature of processing and storage (Berry and Ai-Ti Chen, 1976).

2.61 Aerobic Plate Counts, Total Plate Counts and Standard Plate Counts

Aerobic Plate Counts (APCs) provide an estimate of the total number of viable microorganisms in food according to the medium employed and the time and temperature of incubation (Speck, 1976). The Total Plate Count (TPC) and Standard Plate Count (SPC) estimate the number of living microbial cells present in a food product (Jay, 1978). The terms "APC," "TPC," and "SPC" all refer to the same general procedure. APC is the oldest term used, while TPC is the

newest. The basic procedure for all three methods is essentially the same. Aliquots of food samples are blended, serially diluted in an appropriate diluent, plated in or onto a suitable agar medium, incubated at an appropriate temperature for a given time, and all visible colonies are counted using a Quebec counter (Jay, 1978). In most cases, when the product being analyzed is ground beef, the media of choice is Plate Count Agar (PCA), incubated at 90°F (32°C) for 48 hours.

TPCs are of value to the extent that they indicate the adequacy of sanitation control and temperature control during processing, transport, and storage. They are also useful in revealing sources of contamination during manufacture, and in forming an opinion about incipient spoilage, probable shelf-life, uncontrolled thawing of frozen foods, and failure to maintain refrigerated temperatures for chilled foods (ICMSF, 1978). TPCs, as indicators of sanitary quality in fresh foods, are inadequate in revealing the presence of pathogens (Jay, 1978). TPCs do not specifically identify the class or classes of microorganisms present. Moreover, it is also possible to have bacterial toxin and low total counts in foods because toxin-producing organisms have multiplied and produced toxins that remain stable to conditions that may not favor the continued survival of cells (Jay, 1978). TPCs do not necessarily reveal the kind or likelihood of spoilage in a food product.

2.62 Traditional Microbiological Standards

Traditional microbiological standards for a food product were based on the twin concerns of product safety and shelf-life. The primary objective behind these standards for foods was the protection of the consumer from food poisoning and deteriorating products. Using these traditional standards, a food product was believed to be free of a microbiological hazard provided the level of a specified pathogen or indicator did not exceed a given number per gram or unit (Jay, 1978).

2.63 Sampling Plans

The International Commission on Microbiological Specifications for Food (ICMSF, 1974) has recommended sampling plans to put microbiological sampling on a sound statistical basis. The sampling plan for ground beef recommends both SPC (TPC) and Salmonella counts. As with all attribute plans, the number of sample units from a given lot (n) and the maximum allowable number of sample units that may exceed the microbiological criterion (c) are specified. A novel feature of the ICMSF plans is the existence of three-attribute plans (acceptable-marginally acceptable-unacceptable).

2.64 Salmonellae

Salmonellae are enteric organisms classified in the family Enterobacteriaceae. Salmonellae are gram-positive, asporogenous, motile (by peritrichous flagellae) or non-motile, rod-shaped cells (Bryan, 1968). Based on the

antigens salmonellae possess, approximately 1,400 different serotypes have been identified. Salmonellae are aerobic or facultatively anaerobic organisms (Bryan, 1968). These microbes are ubiquitous, and foods of animal origin have been implicated widely in outbreaks of foodborne diseases associated with these organisms (Ayres, 1969).

Epidemiologic association has been made between ingestion of raw hamburger and the incidence of salmonellosis caused by tartrate-negative, phagetype-two strains of Salmonella typhimurium (Bryan, 1980). Salmonella typhimurium was the serotype most frequently isolated in humans in the United States in 1979 (CDC, 1980). S. typhimurium also was found in samples of ground beef obtained from retail stores (Swaminathan et al., 1978).

Investigations in two states of salmonellosis outbreaks caused by antibiotic-resistant strains of Salmonella newport revealed a significant association between illness and the consumption of raw hamburger (Bryan, 1980). Salmonella infantus has been identified in one sample of ground beef (Shoup and Oblinger, 1976). Salmonella enteritidis ser. worthington has been isolated from ground beef and textured soy protein patties (Foster et al., 1978). Ladiges and Foster (1974) found no salmonellae in any of 100 samples of ground beef and concluded that the raw materials, processing area, and personnel were relatively free of salmonellae contamination.

In the annual summary of foodborne diseases for 1978 issued by the Center for Disease Control in November of 1979, it was reported that salmonellae accounted for over one-third of the confirmed outbreaks (CDC, 1978). Salmonellae outbreaks were caused by a variety of vehicles including meat, poultry, dairy products, salads, and Mexican food. Previous culture surveys of domestic and imported beef by the United States Department of Agriculture have shown Salmonella contamination in 1 to 2 percent of the samples (CDC, 1977). Beef, if improperly handled or improperly cooked, regardless of origin, is a potential source of Salmonella for humans.

In spite of the work that has been done to reduce its incidence, salmonellosis remains one of the major foodborne hazards to human health (Childers, et al., 1973). Increases in the incidence of beef as the source of salmonellosis have been attributed by Cohen and Blake (1977) to such factors as mass production, mass distribution, and the presence of Salmonella in animal feeds. Improper handling of meat could contribute to this increase.

In most foods, salmonellae are easily killed by heat. The effectiveness of a given heat treatment depends on several factors, including the water activity, pH, time, temperature, and the number of organisms (Foster et al., 1970). Salmonellae exhibit growth inhibition at a_w values less than 0.94 in media with neutral pH (Jay, 1978). The pH of optimum salmonellae growth is around neutrality

with values above 9.0 and below 4.0 bactericidal. The best growth takes place in the pH range of 6.6 to 8.2. Salmonellae prefer temperatures ranging from 42°F (5.5°C) to 113°F (45°C), depending on the species (Jay, 1978).

The chief executives of several corporations have established corporate policies stating that their products will not be released for sale if contaminated with salmonellae. Other corporate policies have focused on product temperature control, acceptable storage conditions, and standardized production methods to minimize the health problems associated with salmonellae. Tompkin (1976) suggested that such policies have had a strengthening effect on quality assurance programs.

Microbiological indices of beef quality would appear to be low TPCs and the absence of salmonellae. Although most writers note that non-pathogenic microbial destruction of beef can be attributed to psychrophiles, none has recommended psychrophile counts. In any event, ground beef does not now appear to represent a serious health problem in the United States. Nevertheless, abuse could lead to difficulties so the salmonellae hazard must be regarded as present.

2.7 Nutritional Aspects of Ground Beef

One of the major objectives of food protection programs is to meet consumer expectations. Others have suggested that, to be successful in the foodservice marketplace, the restaurateur should strive to exceed the consumer's expectation level. These expectations are that

food be safe, that it be nutritious, and that it be honestly represented (Nitzke and Christensen, 1979). The increased consumer interest in the nutritional quality of food products was stimulated by the 1969 White House Conference on Food, Nutrition and Health; by the ten-state nutrition survey conducted by the U.S. Department of Health, Education and Welfare; by the Health and Nutrition Examination Survey (HANES); by public statements of nutritionists, consumer advocates, and others concerned about the nation's food supply; and by the need to expand food protection beyond food sanitation. Nutrition has become the subject of controversy in American society, as well as a topic of great interest to industry, government, and the average consumer (Anonymous, 1978).

2.71 Consumer Concern about Nutrition

Consumer concern about the nutritional adequacy of restaurant menus, compounded by impending nutrition labeling regulations for restaurants, increases pressure on foodservice firms to respond with detailed public information on the nutritional quality of restaurant meals (Cichy, 1980). According to Nitzke and Christensen (1980), the consumer concern over nutritional adequacy would logically encourage restaurateurs to respond with detailed, public information about nutritional value. Given the technical complexities of nutrition analysis and the status of governmental regulations, however, it is not surprising that so few restaurants refer to nutrition in advertising and menus (Riggs, 1979).

It is ironic that the government's overwhelming concern for accuracy on labels has posed one of the largest barriers to nutrition labeling. In its eagerness to prevent and punish deception, the government has kept any mention of nutrition out of most restaurant menus and advertisements (Riggs, 1979). However, some fast-food chains, at the urging of the U.S. Food and Drug Administration, have made nutrition information available to customers in their outlets (Anonymous, 1979a).

Today's American consumer wants information on nutrition, food ingredients, and the means to obtain a nutritionally balanced diet (Lachance, 1973). As more and more meals are consumed in foodservice facilities, it becomes increasingly important to evaluate the nutritive value of foodservice meals (Chem and Lachance, 1974). Appledorf (1974) has appealed for documentation of nutrient values of typical limited-menu restaurant meals. Greecher and Shannon (1977) warn that any attempts to improve the nutritive value of restaurant meals must include efforts to lead consumers to make wiser food choices, as well as encourage the foodservice industry to provide rich sources of all nutrients on their menus.

To the extent that a person or a society relies on food from foodservice systems, so ought those systems demonstrate that the customer's faith in the system is well placed. It follows that, whenever claims of nutritional adequacy are made, the entrepreneur must substantiate those

claims. In the final analysis, the emphasis that the restaurateur places on nutrition in the foodservice operation directly depends on the desires of the target market.

2.72 Index of Nutritional Quality

Once the consumer is given nutrient information, that individual is still faced with the task of determining whether or not the food is nutritious. To provide some guidance, nutritionists have developed the Index of Nutritional Quality (INQ), an expression of the nutrient density of a food (Guthrie, 1979). The INQ expresses the relationship between the extent to which a food meets the requirements for a specific nutrient and the extent to which the food meets the needs for energy. The INQ for a food is the percent U.S. Recommended Daily Dietary Allowance (RDA) for each nutrient divided by the percent daily energy requirement.

The degree to which a food satisfies nutrient need is classified as a "source" or "good or excellent source." It has been proposed that a food having an INQ of one or more for four nutrients or an INQ of two for two nutrients makes a "significant" contribution to the nutrient intake and may, therefore, be identified as nutritious (Guthrie, 1979). A food is considered to be a source of a nutrient if it has an INQ of one and if one serving provides at least 2 percent of the U.S. RDA for that nutrient. To qualify as a good or excellent source, the food must have an INQ of 1.5 and provide 10 percent of the U.S. RDA in each serving. Guthrie (1979) claims that easily obtained values in food composition

tables are adequate to predict the nutrient value of foods because they are close enough to values determined by direct chemical analyses.

An important aspect of the evaluation of product quality is analyses of the nutritional characteristics of that product (Lund, 1979). If one recognizes that foods are complex mixtures of biochemicals and that reactions between these chemicals are dependent on many factors in the environment, it becomes obvious that different processes will have varying effects on these biochemicals (Lund, 1979). The major consideration in evaluating food processing, from a nutritional standpoint, is the trade-off between increased food availability and the effects that each of the various kinds of processing have on nutrition.

2.73 Nutrient Retention

Many factors are responsible for the complexity of the problem of nutrient retention. At a minimum, however, the compositional and environmental factors must be considered (Karel, 1979). Even if a menu is correctly planned with the objective of optimal nutrition, many nutrient losses can still take place in the individual unit operations which make up the foodservice sequence: i.e., purchasing, storage, preparation, cooking, holding, and serving (Laughlin, 1961). The critical control points in a good manufacturing practices program to assure optimal nutrient retention would probably be associated with purchasing, prepreparation, cooking, and holding (Livingston and Chang, 1979).

Storage times and temperatures may have a significant effect on nutrient retention in foods. Three stages of the foodservice process appear to require particular attention in terms of nutrient retention: raw material handling, food preparation, and the service of prepared foods (Livingston et al., 1973). The materials and methods involved in food preparation influence the item's nutritional quality (Nitzke and Christensen, 1980). The major sources of nutrient losses during preparation and service of foods of animal origin are thaw drip, cooking drip, nutrient leaching, heat losses, and excessive steam table holding in foodservice operations (Erdman, 1979). The losses, of course, vary with the product considered, the nutrients of interest in the product, and the specific cooking and holding techniques. Commissary or centralized foodservice systems may enhance problems with nutrient retention (Livingston et al., 1973). More research is needed on the nutritional effects of common food preparation processes (Riggs, 1979).

2.8 Sensory Aspects of Ground Beef

Bobeng and David (1977) defined the quality of food as a composite of microbiological, nutritional, and sensory attributes. Sensory methods are used to determine whether foods differ in such qualities as taste, odor, juiciness, tenderness, or texture, and the extent of these differences (Paul and Palmer, 1972). Sensory tests are also used to determine consumer preferences among foods and whether a

certain food product is acceptable to a specified consumer group (Paul and Palmer, 1972).

2.81 Taste Panels

The two general types of sensory evaluations of foods are consumer tests to determine acceptability or preferences and difference tests to determine quality differences. Sensory evaluation is concerned with human evaluation and measurement of physical stimuli (Larmond, 1973). Pangborn (1964) emphasized that laboratory panels are not miniature consumer surveys. Some companies, however, prefer to use employee panels to assess preference or acceptability of a food product before testing that product on consumers (Hirsh, 1971). Employee panels can be utilized to predict consumer acceptability or preference responses, provided the employee panels are composed of persons similar to the potential consumers who will comprise the non-employee panel (Hirsh, 1975).

2.82 Sensory Quality Standards

Sensory quality standards for retail meats may include appearance, such as color, size, and shape; kinesthetics, such as texture, mouthfeel, consistency, and viscosity; and flavor senses, such as taste and smell (Holland, 1979). The purpose of sensory standards is not as much to focus on consumer protection as it is to serve as a means for processors to determine consumer preferences. The objective then becomes the tailoring of the product to satisfy these consumer preferences. Sensory attributes, which are generally

buyer-seller specifications, are ultimately valuable purchasing tools of the consumer (Holland, 1979).

2.82 Sensory Evaluation and Quality Assurance

Sensory evaluation makes an important contribution to an effective quality assurance program. Sensory principles can be applied in all stages of product flow, from incoming inspection to in-process controls to final product inspection and product surveillance (Reece, 1979). Sensory testing has been included in the quality assurance programs of several leading food companies because it offers three important advantages (Nakayama and Wessman, 1979). Sensory evaluation identifies the presence or absence of perceptible differences, pinpoints the important sensory characteristics of a product in a fast, quantifiable manner, and identifies particular problems that cannot be detected with other analytical techniques.

CHAPTER 3

QUALITY ASSURANCE/QUALITY CONTROL ANALYSES

3.1 Hazard Analysis Critical Control Point Concept

The Hazard Analysis Critical Control Point (HACCP) approach is a preventive system of control designed to monitor and minimize the microbiological risks associated with the production of a food product. HACCP entails pinpointing sensitive ingredients, critical process points, and relevant human factors related to product safety (Bauman, 1974). The HACCP procedure has been implemented in quality assurance programs with the hope of preventing mishaps. The HACCP procedure involves analyses of raw ingredients, the processing flow, and the possibility of consumer abuse of the product.

3.11 Hazards Associated with Foodservice Systems

The hazards to which raw materials are exposed are disclosed by an assessment of the product history prior to arrival at the commissary. These hazards would include chemical, biological, and physical contaminants. Analysis of processing hazards involves a determination of whether good manufacturing practices were used, whether the hazards of the process were avoided or eliminated, employee and equipment sanitation, and product packaging and storage

controls. An evaluation of consumer abuse hazards includes the probable methods of product contamination during transportation, distribution, and consumer use.

3.12 Process Flow Diagram

To be effective, the HACCP concept must be applied at each process step in the flow of the product through the foodservice system. HACCP begins with the development of a process flow diagram that includes all pertinent processing factors and details and depicts every stage and step necessary in the operation to produce a given menu item. The process flow diagram is specific for the food, process, equipment, and foodservice system involved (Pettersen and Gunnerson, 1974). Figure 3.120 presents a generalized form of the process flow diagram for the production of the ground beef patty sandwich in the commissary foodservice system under study.

After the process flow diagram has been developed, critical control points are identified. Critical control points are those processing steps during which a loss of control could result in an unacceptable food safety risk. The critical control points vary with the type of foodservice system. The nature of the food product, including pH, chemical composition, water activity, and thermal conductivity, as well as the amount of processing of the product can directly affect the critical control points. Grinding and mixing may enhance the likelihood of microbial contamination and proliferation through the breaking up of

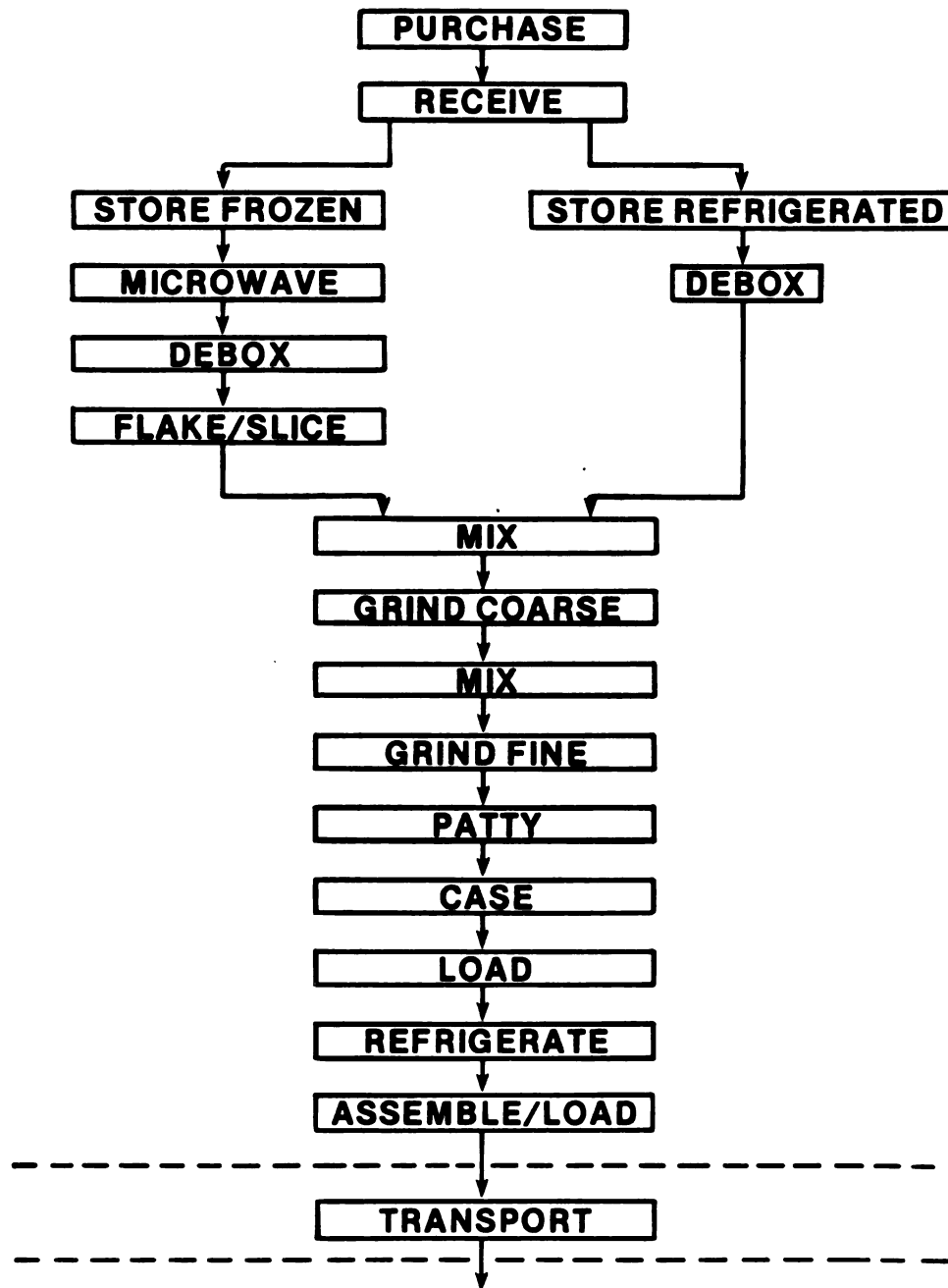


FIGURE 3.120 GENERALIZED PROCESS FLOW DIAGRAM
FOR GROUND BEEF PATTY SANDWICH
PRODUCTION IN A COMMISSARY
FOODSERVICE SYSTEM

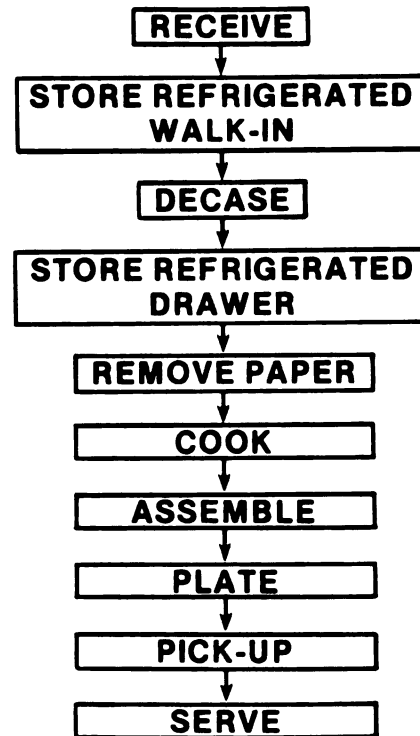


FIGURE 3.120 (CONT'D.)

clumps of microbial cells, generation of greatly increased substrate surface area, aeration, and increased contact and dispersion of contaminants throughout the food mass (Petterson and Gunnerson, 1974).

3.13 Critical Control Points

In general, the critical control points of a food-service system can be classified into four broad categories: ingredient control and storage, equipment sanitation, personnel sanitation, and time-temperature relationships. Ingredient control and storage involves a complete evaluation of incoming ingredients to determine the extent of contamination. Control of incoming ingredients can best be achieved through the development of, and adherence to, standard purchase specifications, detailing in writing the exact quality and quantity desired in a product. These specifications should be the principle focus of all communications between the firm and its suppliers, so they must express as precisely as possible just what the foodservice operation desires. Copies of the specifications should be used by the foodservice's receiving department to check incoming ingredients against what was specified. Receipt of food products is not completed until appropriate test procedures determine the presence of potential hazards and check quality and quantity criteria. The current Meat Receiving form from the commissary under study is included in Appendix A. In-house raw material control is essential to maintain ingredients contamination-free, and retesting of

ingredients during in-house storage is a necessary aspect of ingredient control and storage.

Equipment and facility sanitation is crucial for the prevention and control of microbiological contamination of ingredients and finished products. The key to success in this category of critical control points requires the development and use of detailed cleaning and sanitizing schedules for each piece of processing equipment and area of production. These critical control points should be monitored on a regular basis to determine the effectiveness of the cleaning and sanitizing processes. Personal cleanliness is no less important because human beings are potential carriers of foodborne disease organisms. Foodservice workers must be made aware of the necessity of personal hygiene, grooming, acceptable work uniforms, and foodhandling practices.

Time-temperature critical control points are those at which the possibility for microbiological proliferation exists in a food product. Each raw and finished food product has identifiable maximum storage times that govern quality changes. Refrigerated and frozen storage temperatures will tend to limit these changes, but will not stop quality deterioration entirely. Spoilage of food products can occur if strict time-temperature limits are not obeyed.

Because of the unique nature of a commissary foodservice system, the critical control points are not all under one roof. Therefore, monitoring the critical control

points may be more difficult than initially expected. Since the food products are initially processed in the commissary and then distributed to the individual restaurant for final preparation, the HACCP system must extend to the point of ground beef consumption. The control points associated with production of the ground beef patty sandwich in the commissary foodservice system under study have been identified and listed in Table 3.130. These critical control points were identified after the process flow diagram was developed for this food product.

3.2 The Pareto Principle and Analysis

In 1906, Vilfredo Pareto advanced the theory of a logarithmic law of income distribution (Juran et al., 1962). He observed that the majority of the wealth in a society was held by a minority of the populace. When this idea is applied to the frequency of defects in a product, the unequal distribution is described as the "vital few" versus the "trivial many." The quality assurance personnel can then concentrate their efforts on the "vital few" having distinguished them from the "trivial many" (Juran and Gryna, 1970).

3.21 Objectives of Pareto Principle and Analysis

One of the objectives of quality assurance is to monitor adequately the quality of a product with a minimum of investigation costs. The economics involved in monitoring quality on a regular basis dictate a cost-benefit approach. That is, the greatest benefits should be realized for the costs incurred. This maximizing of resources is

TABLE 3.130 CRITICAL CONTROL POINTS IN THE PRODUCTION OF
A GROUND BEEF PATTY SANDWICH IN A COMMISSARY
FOODSERVICE SYSTEM

CONTROL POINT	CRITICAL CONTROL POINT				TIME- TEMPERATURE RELATIONSHIP
	INGREDIENT CONTROL AND STORAGE	EQUIPMENT SANITATION	PERSONNEL SANITATION		
Purchase	X				X
Receive	X				X
Store frozen	X				X
Store refrigerated	X				X
Microwave					
Debox		X	X		X
Flake/slice		X	X		X
Mix		X	X		X
Grind coarse		X			
Mix		X	X		X
Grind fine		X			
Patty		X			X
Case					
Load		X	X		X
Refrigerate					X
Assemble/load	X				X

TABLE 3.130 (CONT'D.)

CONTROL POINT	CRITICAL CONTROL POINT				TIME- TEMPERATURE RELATIONSHIP
	INGREDIENT CONTROL AND STORAGE	EQUIPMENT SANITATION	PERSONNEL SANITATION		
Transport					X
Receive					X
Store refrigerated walk-in	X				X
Decase			X		
Store refrigerated drawer	X				X
Remove paper			X		
Cook		X	X		X
Assemble	X	X	X		
Plate		X	X		
Pick-up			X		X
Serve			X		X

extremely important because there are both time and personnel limits to the amount of inspection and sampling which can be conducted. The Pareto analysis provides a rational method for focusing on those pieces of equipment or practices that should receive the most attention from the quality assurance staff. These "vital few" are the leading critical items on which the quality assurance efforts should hinge.

3.22 Swab Test Methods

The Pareto principle and analysis was applied to previously recorded results of the existing, routine, microbiological survey of the patty-forming and accessory equipment in the commissary meat room. Twenty-three pieces of equipment were swabbed on a regular basis during the pre-operation inspection and Total Plate Counts (TPCs) recorded. A brief description of each of these swab sites is in Appendix B. The lab staff used Falcon TM disposable cotton-tipped Swube^R applicators, number 2009, to take the swab tests. The tube had a sterile swab solution added prior to conducting the test, which was subsequently plated without diluting on plate count agar (PCA) and incubated at 90°F (32°C) for 24 hours. Colonies were counted with the aid of a Quebec colony counter and the results were entered in the lab notebook.

The four pieces of equipment were selected on a "random" basis and four swabs were collected on two different days of each week. The quality assurance lab staff member

concentrated on the swab sites that have had two or three recent TPCs resulting in too numerous to count (TNTC) colonies. In the present system, there is no logical approach to selecting the swab sites, nor has the number of TNTC results been reduced as would be the case in an effective system.

3.23 Swab Test Results

The results of the swab tests for a seven-month period (February 1980 through August 1980) fall naturally into three categories: low, intermediate, and high. These data are summarized in Table 3.230. The quality assurance pre-operation inspector was asked to determine the extent of contact that the meat had with each swab site. The categories established were heavy, moderate, and light contact.

3.24 Priority Rankings

The TPCs were assigned a score from 1 (high) to 3 (low). The extent of meat contact was similarly scored from 1 (heavy) to 3 (light). A priority ranking, representing the mathematical product of the historical TPCs and meat contact scores, was established for each of the 23 swab sites. These scores and priority rankings are listed in Table 3.240. The priority ranking was used to redefine the inspection practices: frequency and location. The priority ranking indicates that the seven sensitive swab sites with the highest priority ranking (ranking 1) should receive the most attention.

TABLE 3.230 TOTAL PLATE COUNTS (TPCs) FROM SWAB TESTS
ON SELECTED EQUIPMENT LOCATIONS IN THE
COMMISSARY MEAT ROOM¹

CATEGORIES OF TPC RESULTS, COLONIES/16 SQUARE INCHES							
SWAB SITE	LOW (<1 TO 1001)		INTERMEDIATE (1001 TO $<$ TNTC)		HIGH (TNTC)		TOTAL NUMBER OF SWABS TAKEN
	NO. 2	% OF TOTAL	NO. 2	% OF TOTAL	NO. 2	% OF TOTAL	
Hydraflaker table	5	40	2	20	5	40	12
Hydraflaker blade	5	70	-	-	2	30	7
Conveyor #1 belt	12	75	-	-	4	25	16
Conveyor #1 side	11	100	-	-	-	-	11
Conveyor #2 belt	4	45	1	10	4	45	9
Conveyor #1 top	1	20	1	20	3	60	5
Hopper #1	3	100	-	-	-	-	3
Grinder #1 throat	10	70	1	10	3	20	14
Grinder auger	13	80	2	15	1	5	16
Grinder blade	5	100	-	-	-	-	5
Hopper #2 cover	-	-	-	-	2	100	2
Grinder #2 throat	2	70	1	30	-	-	3
Formax hopper	7	90	1	10	-	-	8
Formax plates	2	50	1	25	1	25	4
Formax auger	3	100	-	-	-	-	3
Formax conveyor belt	12	55	3	15	6	30	21
Formax plunger	1	100	-	-	-	-	1

TABLE 3.230 (CONT'D.)

CATEGORIES OF TPC RESULTS, COLONIES/16 SQUARE INCHES									
SWAB SITE	LOW (<1 TO 1001)		INTERMEDIATE (1001 TO <TNTC)		HIGH (TNTC)		TOTAL NUMBER OF SWABS TAKEN		
	NO.	2	%	OF TOTAL	NO.	2	%	OF TOTAL	
Paper chute	-	-	-	-	-	-	-	-	2
Shovel	4	70	-	15	1	1	100	15	6
White tub	4	50	1	10	1	3	40	40	8
Sst tub	3	75	1	25	-	-	-	-	4
Barrel	1	30	-	-	2	2	70	70	3
Scoop	2	100	-	-	-	-	-	-	2

¹Based on historical TPC results from February 1980 through August 1980.

²Number refers to the number of instances of taking a swab at the indicated site.

TABLE 3.240 TPCs AND MEAT CONTACT SCORES AND PRIORITY RANKINGS OF SELECTED EQUIPMENT LOCATIONS IN THE COMMISSARY MEAT ROOM

SWAB SITE	SCORE		PRIORITY RANKING ²
	TPC	MEAT CONTACT ¹	
Hydrauflaker table	1	1	1
Hydrauflaker blade	1	1	1
Conveyor #1 belt	1	1	1
Conveyor #2 belt	1	1	1
Conveyor #1 top	1	1	1
Grinder #1 throat	1	1	1
Grinder auger	1	1	1
Grinder #2 throat	2	1	2
Formax plates	1	2	2
Shovel	1	2	2
White tub	1	2	2
Hopper #1	3	1	3
Grinder blade	3	1	3
Formax auger	3	1	3
Hopper #2 cover	1	3	3
Formax conveyor belt	1	3	3
Paper chute	1	3	3
Barrel	1	3	3
Formax hopper	2	2	4
Sst tub	2	2	4
Conveyor #1 side	3	2	6
Formax plunger	3	2	6
Scoop	3	2	6

¹1 = heavy, 2 = moderate, 3 = light meat contact.

²Represents the mathematical product of the historical TPCs and meat contact scores.

Priority rankings for the swab sites in the meat room provided the quality assurance staff with a rational tool for use in identifying critical locations. The staff was then able to focus attention on the most serious sources of contamination. The Pareto analysis, coupled with a technical review of this operation, provided a rational means for selecting leading critical locations requiring high priority for corrective action (i.e., action to reduce additional microbial contamination).

The initial emphasis of the swab tests was on the sensitive locations having the highest priority ranking. Once this equipment was cleaned and kept clean, priority rankings were recalculated. This reranking is done to update the "vital few" and "trivial many" categories.

The quality assurance staff requires the full cooperation of the sanitation crew for the program to be successful. The priority ranking report generated by quality assurance can be used to redirect the sanitation crew's efforts to the "vital few" critical areas. This report provides the basis for action on the part of the sanitation crew and the criteria for evaluation of the sanitation crew's efforts.

3.3 Production of Ground Beef Patties

The commissary meat room produces approximately 17 tons per week of the ground beef patties under investigation in this study. This volume accounts for over 55 percent of the total annual ground beef production, which is

in excess of 1,500 tons. Each patty weighs approximately 1.6 ounces (45.4 grams). The stacks of finished patties are packed into plastic bags placed in plastic lugs of approximately 25 pounds each.

The commissary produces the ground beef patties from fresh and frozen boneless beef (nominally 85 percent lean and 15 percent fat) and beef plates (nominally 50 percent lean and 50 percent fat). The lean fraction is about 60 percent moisture. The fresh beef is purchased weekly in the state and Canada, while the frozen beef is shipped from Australia, Canada, and New Zealand less frequently, depending on market supply and price. There are no detailed, written standard purchase specifications for either product.

The meat is delivered to the commissary by common carrier. The receiving department performs no inspection of the delivery truck, but does verify, by count, the number of incoming 60-pound boxes of frozen meat. Usually, six to ten of the frozen boxes are set aside for lab tests to determine total plate counts (TPCs) and percent fat, but no similar analysis of fresh meat is undertaken. Fresh meat is delivered at the commissary in 2,000-pound containers. No verification of either fresh or frozen product weight is done.

The commissary produces the ground beef patties in the meat room, using the steps outlined in the process flow diagram (Figure 3.120). A combination of fresh and frozen plates and frozen boneless beef is used to prevent patty

formation problems, such as the sticking of the meat in the Formax machine when all fresh is used. This combination improves the texture of the patty and minimizes patty deformation. The beef plates are mixed with the boneless beef for flavor contribution.

The batch master, who has worked in the meat room for over 15 years, decides, on the basis of the look and feel of the ground beef, when the batch has the correct composition. The lab staff also determines the percent fat in the patties by a modification of the Babcock procedure, the desired final patty composition being 78 percent lean and 22 percent fat. The weight of the patties is thought to be controllable by making adjustments to the patty machine.

3.4 Analysis of Patty Weights

The ground beef patties are made with a Formax patty machine fitted with a four-hole die and having a capacity of 200 patties per minute (1,200 pounds per hour). The machine is fed from a hopper having a holding capacity of 500 pounds. Several raw product factors may influence the densities and, therefore, the final weight of the patties. Percentages of fat, amounts of fresh or frozen boneless beef and beef plates, and the product temperature may influence the patty weight. Machine setting and other factors that may affect the patty weight probably include the temperature of the meat room, the size of the die, machine speed, the pressure setting on the patty machine, and the amount of product in the hopper.

3.41 Data Collection

Ground beef patty weights were recorded on six different days at the commissary. On each date, the following information was collected: batch--indicating a single, reasonably homogeneous combination of the separate beef and beef fat ingredients, usually 500 pounds, and to which no further adjustments or additions are made; sample--the number of series of 40 patties collected from a single batch; position--1, 2, 3, or 4, meaning the die location reading from left to right facing the exit part of the machine; replicate--one through ten, meaning the order of production was preserved; weight--individual net patty weight in grams; and psi--the pressure setting in pounds per square inch on the machine at the time the patties were formed. These data are presented in Appendix F and summarized in Table 3.410.

Patty weights were recorded with a top-loading Mettler digital readout display analytical balance, accurate to 0.01 grams. The balance was zeroed and checked to be certain it was level before weighing each group of 40 patties. The patty machine automatically places a paper separator between each patty. An unused paper separator was weighed and the patty was placed on top of the paper and the total weight was recorded. The paper separator that had been added by the patty machine was removed (as it would be at the restaurant) prior to recording the patty weight. Net patty weights were calculated by taking the difference between

TABLE 3.410 SAMPLING SCHEDULE FOR THE PROCESS CAPABILITY STUDY AND THE ANALYSIS OF COVARIANCE OF NET PATTY WEIGHTS

DATE, 1980	PSI	NUMBER OF	
		BATCHES	PATTIES
August 26	150	3	120
August 26	140	2	80
September 4	125	1	40
September 23	140	1	40
September 29	140	4	160
October 7	130	1 ¹	160
October 21	140	1 ¹	160
Total		13	760

¹Four forty-patty samples.

the patty plus the unused separator and the weight of the paper separator.

3.42 Covariant Analysis

An analysis of covariance was performed on all 760 patty weights using the GENSTAT V program on the Cyber 750 computer system at Michigan State University. The covariant was psi and the results looked at the effect of this regression variable and position, sample within batch, replicate, and batch on the dependent variable, weight. The GENSTAT V program adjusted the data to an average psi to allow analysis of the other independent effects. The model used for the analysis of covariance was:

$$\begin{aligned} \text{weight} = & \mu + \text{batch} + \text{sample within batch} + \text{position} \\ & + \text{replicate} + \text{position by replicate} + \beta \\ & \times \text{psi} + \text{error} \end{aligned}$$

This mixed model assumes that batch, replicate, and sample are all random and that position is fixed.

3.43 Percent Fat in the Pretest vs. Percent Fat in the Patty

The percentage of fat in the fresh and boneless beef, beef plates, and finished patties is measured routinely by the commissary lab staff, using a variation of the Babcock test. Glacial acetic acid (50 percent) plus perchloric acid (50 percent) were combined with a nine-gram sample of meat in a Paley bottle. The sample was hydrolyzed for approximately 15 minutes in a water bath at 208°F (98°C). After digestion, more of the acetic-perchloric acid was added to force the fat to rise in the neck of the Paley

bottle. A few drops of glymol (mineral oil) were added to depress the meniscus and the percent fat was read with the aid of calipers.

The percent fat was recorded on the Meat Daily Weight and Fat Report included in Appendix A. The firm's stated objective is to produce a patty with 22 percent fat and 78 percent lean. Because fat is less dense than muscle tissue, the influence of the percent fat found during the pretest ought to be correlated with the percent fat in the finished patty unless the meat room batch master is able to make adjustments. Thirty-four pairs of numbers (see Appendix C), representing the percent fat in the pretest and the related percent fat in the post test were analyzed with the aid of the Interactive Data Analysis (IDA) program on the Hewlett Packard system at Michigan State University.

The IDA program used least-squares linear regression to predict a dependent value (percent fat in the patty) from an independent value (percent fat in the pretest). The program assumed a linear relationship between x and y , determined by evaluating the scatter plot of the data. If the scatter plot reveals a linear relationship, then linear regression may be an adequate predictive model. The correlation between x and y must also be checked, because a high positive correlation indicates that the independent variable will be a good predictor of the dependent variable. If both the check of the scatter plot and the correlation

yield credible results, regression can be used as a predictor.

When analyzing the results to determine whether regression is a good predictive model, the residuals (error terms) must be evaluated in each of the following three areas: normality, independence, and homoscedasticity (Ling and Roberts, 1980). Normality indicates that the residuals are distributed along a normal probability distribution. The normality of the residuals was checked by using a normal cumulative probability plot of the residuals. If the errors are not normal, regression analysis is still acceptable because regression is robust with respect to normality. Therefore, the model is unaffected by the fact that the errors are not normally distributed and the model can still be used as a predictor. Although normality is important, the regression model has been shown to be robust with respect to non-normality so it is not necessary to expend an effort to analyze for normality.

Independence means that the errors occur randomly, and that the error terms are not related to, or influenced by, each other or the independent variable. If the residuals are not independent, the regression coefficient will be biased, indicating that the value to be predicted will be either too low or too high in relation to the true value. The independence of the residuals was determined by inspecting a sequence plot of the residuals and evaluating the autocorrelation function.

Homoscedasticity refers to the errors or residuals having a constant variance through time. The amount of error through time is constant; therefore, the residuals are stationary with a constant mean. The residuals are all expected to have a mean of zero. Homoscedasticity is a necessary condition; otherwise regression cannot be used to predict the dependent variable from the independent variable. Homoscedasticity was determined by using a scatter plot of the residuals vs. the fitted values.

3.44 The Percent Fat in the Pretest vs. Patty Weight

The regression program was also used to evaluate whether or not the patty weight could be predicted from the percent fat in the pretest. Using 113 pairs of data points (see Appendix D), a regression was run with patty weight as the dependent variable. The IDA program tested the data for independence, normality, and homoscedasticity. The coefficient of determination, R^2 , measured the proportion of variance in patty weight that could be attributed to the percent fat in the pretest.

3.5 Process Capability Analysis of Patty Weights

A process is a combination of materials, machines, methods, and people used to create a product (Juran et al., 1962). A process capability analysis is a method for correcting an existing problem with a process, if that problem can be corrected. A complete process capability analysis consists of several key components. First, the specification tolerance must be established. In the case of the

ground beef patty production in this commissary foodservice system, the factor studied was patty weight. The commissary currently specifies a patty weight of 45.4 grams $\pm$ 1 gram for each patty produced. The objective is to produce ten patties to a pound of ground beef.

Next, the process capability analysis determines where, along the scale of measurement, the process is "centered." The procedure identifies whether or not the process is inherently capable of meeting the specified tolerances. In addition, the analysis aids in management decisions on whether it is economically feasible to reduce the variability so as to increase conformity to the established tolerances.

3.51 Specifics of a Process Capability Analysis

A process capability analysis begins with obtaining certain information about the product under study. Specifically, the product name, unit inspected, the machine/line, the inspector, the quality factor, and the specification with the minimum and maximum tolerances were all recorded. Preserving the order of collection, the data was collected and tabulated in $\underline{n}$ -unit groups until $\underline{k}$ groups were assembled. In the process capability analysis of patty weights, a total of 760 ($\underline{n} = 4$ and $\underline{k} = 190$) samples were collected during six different visits to the commissary.

Next, the mean, $\bar{x}$, and the range, R , of each $\underline{n}$ -unit group was computed and recorded. The average range $\bar{R}$ was calculated by taking the sum of the $\underline{k}$ ranges and dividing

by $\bar{k}$. The upper and lower three-sigma limits of the range were then computed using $\bar{R}$ and the appropriate D_3 and D_4 factors from ASTM (1951). The observed ranges were then examined and any that were outside of the three-sigma limits were discarded. These values were removed on the grounds that they very likely came from assignable causes and, if the values were left in, the true capability of the process would less likely be determined.

The average range and new limits were then recalculated and the data were reexamined to determine which ranges were outside of the new limits. This process was repeated until all of the remaining ranges fell within the limits last calculated. The standard deviation was then estimated from the final $\bar{R}$ and the appropriate d_2 factor from ASTM (1951). The standard deviation measures the piece-to-piece variability (Juran and Gryna, 1970).

The observed average value of the patty weights, $\bar{\bar{X}}$, was then calculated from the sum of the individual $\bar{x}$ -unit means. The grand average measures the centering (aim) of the process (Juran and Gryna, 1970). The next step involved the construction of frequency and cumulative frequency distributions. The $\bar{n}$ individual measured values, x_i , were sorted and placed into suitable equal-sized intervals and the number of x_i 's in each interval was counted. The number of intervals, j , was calculated by Sturgis's rule and they covered a span of the natural limits of the process, six standard deviations. Both interval size and

interval boundaries were calculated and the number of x_i 's in each interval was tallied. Finally, the frequency (percentage) histogram and the cumulative percentage (normal probability) plot were constructed and analyzed. This analysis leads to an identification of the causes of the differences between inherent and actual variability.

3.52 Alternative Courses of Action

Juran and Gryna (1970) suggested several alternative courses of action to eliminate defective work, depending on the results of the process capability analysis. If it is concluded that the process is capable of meeting the specified tolerances, it would be necessary to recenter the process aim. On the other hand, if the process is not capable of meeting tolerances, either the tolerances should be widened or a basic process change must be made. Alternatively, the organization could sort defectives. All of these possible courses of action have economic implications: changing a process may require an investment in capital; widening a tolerance could reduce the value of a product and adversely affect the firm's market share. Ultimately, the decision of whether or not to alter a process is one that must be made by management, based, in part, on a cost-benefit analysis.

3.6 Microbiological Analyses

The commissary lab monitored the microbiological condition of incoming raw fresh and frozen beef on a sporadic basis. The attention to such collection directly depended

on the lab staff's workload and the number of staff members working on a given day. With a finite number of resources available, the lab staff concentrated on the products produced within the commissary rather than the products received by the commissary for processing.

In addition to raw and finished product microbiological analyses, the lab staff also performs surface swabs of meat room equipment. Total Plate Counts (TPCs) on the finished ground beef patty were used as indicators of product quality. The United States Department of Agriculture (USDA) inspector also looked at TPCs weekly since this commissary had a pre-approved program.

3.61 Total Plate Counts

The lab staff relies on Total Plate Counts (TPCs) to evaluate the microbiological condition of incoming raw products and products produced in the commissary. TPCs refer to the total number of living organisms in a sample. Prior to plating, the sample was diluted from 10^{-2} through 10^{-6} , since the counts are usually relatively high on ground beef. The media of choice was PCA, and single plates of each dilution were incubated at 90°F (32°C) for 48 hours. The lab staff used dehydrated Bacto-PCATM, which was rehydrated in the lab.

After incubation, the number of colonies, on plates containing between 30 to 300 colonies, was determined with the aid of a Quebec counter. TPCs are of value for the total number of living microorganisms present with no

indication as to the type of microbes. Specific microorganisms can be enumerated from a sample by utilizing other combinations of media and time-temperature of incubation.

The original raw product receiving procedures at the commissary specified that TPCs should be determined on six to ten "randomly" chosen boxes of meat. The accept-reject decision was based on the USDA's recommended limits of <100,000 organisms/gram TPC. However, due to resource limitations relative to time and staff, the lab decreased the emphasis on incoming product evaluation. The inspection of incoming frozen beef was done more regularly than that of incoming fresh beef.

TPCs were also obtained from meat room equipment using a modification of the above procedure. Four of the 23 swab sites described under the Pareto principle and analysis section were selected at "random" on both Tuesdays and Thursdays. After the location was swabbed with the Swube tube containing the sterile solution, the solution was plated directly with no dilutions on PCA. One plate was incubated at 90°F (32°C) for 48 hours for each of the four locations. The TPC was estimated by counting four grids on the Quebec Colony Counter, taking the average, and multiplying by 65 (total number of grids). Results were reported as colonies/16 square inches of surface area.

The swab tests are taken during the lab staff member's early morning pre-operation inspection of the meat room. In addition to the swabs, the Daily Commissary Sanitation

Meat Department form (Appendix A) is filled out by the lab inspector.

The USDA inspector monitors these TPC values weekly; however, the burden of maintaining the standards is on the organization rather than the government. The inspector does not look for any specific numerical values but evaluates the overall picture, basing 85-90 percent of the inspection on sight, smell, and taste. The inspector does not monitor patty product weights, since no pre-operation agreement has been established to check net patty weights.

3.62 Salmonellae Testing

Due to limitations of available resources, the commissary lab staff only does TPCs on the products produced in the commissary. During this study, Salmonella testing was undertaken at a state Department of Agriculture laboratory. On four different ground beef patty production dates, five field samples of one pound each were obtained from the commissary. The field samples were placed in Zip-loc plastic bags, packed in an ice-filled Thermos cooler, and delivered to the state Department of Agriculture laboratory.

The state laboratory analyzed the samples for the presence of Salmonella utilizing the procedure in the Food and Drug Administration's (FDA) Bacteriological Analytical Manual (1976), with the modifications noted in Appendix E. The state lab staff also evaluated each of the raw field samples based on the sensory factors of odor, appearance, texture, and color. In addition, one or two patties from

each field sample was cooked and evaluated for acceptable odor and taste by the state laboratory staff.

3.63 Time-Temperature Relationship

The time-temperature relationship is one of the critical control points of paramount importance during the production of the ground beef patty sandwich in this commissary foodservice system. Eighteen of the 27 control points listed in Table 3.130 are associated with the time-temperature relationship.

The time-temperature history was recorded on three separate randomly chosen dates for each of the following critical control points: store frozen, store refrigerated, pre-microwave, post-microwave, flake/slice, hopper/grinder number one, hopper/grinder number two, Formax hopper, patty, refrigerated patties--just produced, refrigerated patties--one-day old, transport, store-refrigerated walk-in, store-refrigerated drawer, cook, and serve. The internal product temperature of the fresh and frozen raw beef and that of the finished patties was obtained with a Wahl Digital Platinum-RTD Heat ProberTM Thermometer model number 350X. The accuracy of this instrument was $\pm 2^{\circ}\text{F}$ ($\pm 1^{\circ}\text{C}$). Product temperatures were recorded to the nearest $\pm 0.2^{\circ}\text{F}$ (0.1°C).

An ice pick was inserted to the geometric center of the boxed fresh and frozen meat prior to inserting the digital thermometer's sensing probe. Hopper temperatures were obtained by inserting the probe in five different locations and averaging the readings. Individual patty

temperatures were determined by inserting the probe horizontally into the patty for maximum probe surface to meat contact. Average patty temperatures in the 25-pound cases were obtained by determining the temperature of one patty chosen from the top, center, and bottom of the case and taking the average.

Since commissary foodservice systems typically produce and serve their menu items in separate locations, the time-temperature relationship during transportation and distribution is extremely important. The environmental temperature of the ground beef patties was recorded from the time the 25-pound cases were placed in the commissary's refrigeration unit through delivery of the product to the restaurant's walk-in refrigerator. A Pacific Transducer Corporation Model Number 615 Portable Dry Stylus Recording Thermometer with an accuracy of $\pm 2^{\circ}\text{F}$ ($\pm 1^{\circ}\text{C}$) was placed in the corner of a case of recently produced patties.

Environmental storage temperatures in the commissary walk-in freezer and refrigerator were also determined. In addition, the restaurant walk-in cooler and refrigerated drawer ambient temperatures were measured. All of these storage area temperatures were determined with a Cooper refrigerator/freezer portable thermometer model number 25HP with an accuracy of $\pm 2^{\circ}\text{F}$ ($\pm 1^{\circ}\text{C}$). The thermometer was placed near the stored product and the temperature was read 30 minutes later.

Because the likelihood of microbiological proliferation is influenced by both time and temperature, maximum holding times in each of these 16 critical control points were determined from commissary records and interviews with both commissary and restaurant personnel. The time periods varied from a maximum of two months during freezer storage holding of the raw beef to one minute during the flake/slice operation. Using the temperature danger zone established by the U.S. Public Health Service, the time-temperature history of this product can be utilized to estimate the likelihood of microbiological proliferation.

3.7 Nutritional Analysis of Ground Beef Patties

The nutritional quality of any food is a function of its chemical composition as related to the specific nutrient needs of the individual. Unfortunately, the exact composition of foods and nutrient requirements of individuals are usually incompletely known (Hansen et al., 1979). Moreover, the nutrient content of a food product is dependent to some extent on such factors as the production, processing, and storage conditions prior to consumption.

The precise description of the nutrient content of a food is also limited by the availability of the nutrient under consideration and the synergistic effect of various food combinations. In addition, nutrient losses can be experienced in meat products, particularly during thawing, cooking, and holding (Erdman, 1979). The nutrient content of specific food items can be determined through complex

chemical analyses (Appledorf, 1974). Beyond that, the nutrient profile of a menu item can be estimated through the use of tables of food composition (Guthrie, 1979). In order to compare the nutrient profile of the ground beef patties in this study to an individual's nutritional needs, several assumptions were made regarding target market age group, average weight and height of the target market group, and average energy need of this group.

3.71 Recommended Daily Dietary Allowances

The Food and Nutrition Board of the National Academy of Sciences - National Research Council Recommended Daily Dietary Allowances (RDA), revised in 1980, were reviewed to determine the nutrient values for both males and females. For the purposes of nutrition analysis of the ground beef patties, the age group of 23 to 50 years was selected. The corresponding portion of the RDA for this age group is presented in Table 3.710. These values assume an average weight of 154 pounds (70 kilograms) and height of 70 inches (178 centimeters) for the male, and an average weight of 120 pounds (55 kilograms) and height of 64 inches (163 centimeters) for the female. Based on the RDA, the average daily energy need was assumed to be 2,700 kcals. for the male and 2,000 kcals for the female.

3.72 Food Composition Tables

Data from food composition tables provide the least expensive, yet most widely used, tool for estimating the nutrient intake of an individual (Guthrie, 1979). These

TABLE 3.710 RECOMMENDED DAILY DIETARY ALLOWANCES
FOR SELECTED NUTRIENTS FOR MALES AND
FEMALES IN THE 23 TO 50 AGE GROUP

RECOMMENDED DAILY DIETARY ALLOWANCES		
NUTRIENT	MALE	FEMALE
Protein (g)	56	44
Vitamin A (μ g RE) ¹	1000	800
Vitamin D (μ g) ²	5	5
Vitamin E (mg α TE) ³	10	8
Ascorbic Acid (mg)	60	60
Thiamin (mg)	1.4	1.0
Riboflavin (mg)	1.6	1.2
Niacin (mg NE) ⁴	18	13
Vitamin B ₆ (mg)	2.2	2.0
Folacin (μ g)	400	400
Vitamin B ₁₂ (μ g)	3.0	3.0
Calcium (mg)	800	800
Phosphorus (mg)	800	800
Magnesium (mg)	350	300
Iron (mg)	10	18
Zinc (mg)	15	15
Iodine (μ g)	150	150

¹Retinol equivalents. 1 RE = 1 μ g retinol or 6 μ g β carotene or 3.33 IU.

²As cholecalciferol. 10 μ g cholecalciferol = 400 IU Vitamin D.

³ α tocopherol equivalents. 1 mg d- α -tocopherol = 1 α TE.

⁴Niacin equivalents. 1 NE = 1 mg niacin or 60 mg dietary tryptophan.

data are usually based on information extracted from one or both of the following sources: the U.S. Department of Agriculture Handbook, No. 456, Nutritive Value of American Foods (1975); or the U.S. Department of Agriculture Home and Garden Bulletin No. 72 (1977). The data for Handbook No. 456 originally was printed in the U.S. Department of Agriculture Handbook No. 8, Composition of Foods--Raw, Processed, and Prepared, which was initially published in 1950. This publication lists food values in terms of 100 grams edible portion (EP) and one pound as purchased (AP). Bulletin No. 72, on the other hand, expresses food values in terms of average servings or common household units.

The data for this study were taken from Handbook No. 456 because this facilitated the conversion to the values needed in this analysis. The values used were based on regular raw and cooked ground beef with an average fat content of 21 percent. These values were adjusted to the grand mean value, $\bar{X}$, obtained for the patty weights in the process capability analysis. Since each ground beef sandwich contains two patties, the grand mean value of 44.3 grams was multiplied by two to obtain the total precooked weight of the patties, or 88.6 grams. The values of the various nutrients present in the ground beef patties were obtained by taking a ratio of the cooked to raw values from Handbook No. 456. These values are presented in Table 3.720.

Since the patties are cooked on a griddle in the restaurant, the values represented in Handbook No. 456 are

TABLE 3.720 COMPOSITION OF RAW AND COOKED GROUND BEEF
PATTIES WITH 21 PERCENT FAT BASED ON
VALUES IN USDA HANDBOOK NO. 456

ITEM	PRODUCT		LOSS, %
	RAW GROUND BEEF	COOKED GROUND BEEF	
Weight (g)	88.6	63.6	28
Moisture (%/g)	(60.2/53)	(54.2/35)	35
Food energy (kcal)	273	210	23
Protein (g)	15.8	15.4	3
Fat (g)	18.8	13.0	31
Carbohydrate (g)	0	0	0
Calcium (mg)	8.8	7.0	21
Phosphorus (mg)	138.1	122.9	11
Iron (mg)	2.4	2.0	17
Sodium (mg)	55.4	37.7	30
Potassium (mg)	253.3	172.2	30
Vitamin A (μ g RE)	103.9	77.9	25
Thiamin (mg)	0.10	0.08	20
Riboflavin (mg)	0.10	0.09	10
Niacin (mg NE)	3.8	3.4	11
Ascorbic acid (mg)	0	0	0

applicable. No attempt was made to estimate the nutrient contents of the cheese, special sauce, lettuce, and french fries added to the patties before service. In spite of the recognized limitations, the food composition tables permit estimates of the nutritive content of a food item that approximate those values determined by direct chemical analyses. The advantages of using these tables include lower costs in time, equipment, and money.

3.73 Index of Nutritional Quality

The Index of Nutritional Quality (INQ) is one expression of the nutrient density of a food. That is, the INQ expresses the relationship between the extent to which a food meets the requirement for a specific nutrient compared to the extent to which it meets an individual's needs for energy (Guthrie, 1979). Mathematically, the INQ is calculated as follows:

$$\text{INQ} = \frac{\text{Percent U.S. RDA for a nutrient}}{\text{Percent energy requirement}}$$

If a food has an INQ of one or more for four nutrients or an INQ of two or more for two nutrients, that food makes a so-called significant contribution to the individual's nutrient intake and it may be identified as nutritious. A food is considered a so-called source of a nutrient if it has an INQ of one, and one serving of that food provides at least 2 percent of the U.S. RDA for the nutrient. The food must have an INQ of 1.5 and provide 10 percent of the U.S. RDA in each serving to be categorized as a good or excellent

source. The percent RDA and the INQ were calculated for the following eight nutrients present in the ground beef patties: protein, calcium, phosphorus, iron, vitamin A, thiamin, riboflavin, and niacin. The results of these calculations are presented in Table 3.730. Based on these values, the ground beef patties were classified as nutritious, and whether or not they were merely a source or a good or excellent source of each of the individual nutrients.

3.8 Sensory Analysis of Ground Beef Patties

Sensory evaluation can be considered a service function regardless of where or how it is positioned in an organization. Hirsh (1971) observed that, ideally, this service function should be an integral part of the decision-making continuum. Sensory evaluation may be structured as strictly a part of research and development. Alternatively, sensory evaluations of the firm's products can provide information to bridge the gap between the research and development department and the promotional aspects of marketing. In addition, sensory evaluation can be used as a branch of marketing research to check advertising, market positioning, and packaging rather than the physical and quality aspects of the product itself.

3.81 Sensory Evaluation at the Commissary

The commissary receiving department performs no sensory evaluation of the delivered fresh or frozen beef plates, or boneless beef. Only the number of boxes delivered are verified and compared to the invoice. The lab staff

TABLE 3.730 THE PERCENT RDA AND THE INDEX OF
NUTRITIONAL QUALITY FOR EIGHT
SELECTED NUTRIENTS IN GROUND
BEEF PATTIES

NUTRIENT	PERCENT RDA		INDEX OF NUTRITIONAL QUALITY	
	MALE	FEMALE	MALE	FEMALE
Protein	27.5	35.0	3.5	3.3
Calcium	0.9	0.9	0.1	0.1
Phosphorus	15.4	15.4	2.0	1.7
Iron	20.0	11.1	2.6	1.1
Vitamin A	7.8	9.7	0.7	0.8
Thiamin	5.7	8.0	0.7	0.7
Riboflavin	5.6	7.5	2.4	2.5
Niacin	18.9	26.2	1.0	0.7

performs odor, color, and appearance checks, in addition to TPC and percent fat tests, on "randomly" chosen samples of frozen beef delivered to the commissary.

When the fresh and frozen beef is processed by the meat room personnel, the product is evaluated by the meat room supervisor based on appearance, odor, and texture. The lab staff informally evaluates the finished ground beef patties, based on sensory criteria of odor and appearance, when analyzing the product for percent fat. The USDA inspector at the commissary primarily performs a sensory inspection (sight, smell, and touch) of the patties. This individual conducts no analytical tests, but relies on the results of the commissary lab analyses. The USDA inspector relies on his experience to indicate whether or not the product is acceptable.

3.82 Taste Panels

Periodically, an "executive" taste panel consisting of the commissary owners, the vice-president for commissary operations, the commissary manager, and the individual in charge of all retail operations evaluates selected food products. The form used for this evaluation is included in Appendix A. The taste panel utilizes preference tests to evaluate food products based on individual likes or dislikes. Menu items are added or deleted based on the preferences of the "executive" taste panel.

The danger in only using an "executive" taste panel lies in the fact that panel members may not accurately

reflect the target market's preferences. The goal of sensory evaluation should be to determine whether the product offered is in a condition that is satisfactory to the consumer (Wren, 1977). This consideration should pervade all aspects of quality assurance, especially the area of sensory analysis.

In addition to evaluating the field samples for the presence of Salmonella, the state Department of Agriculture laboratory also checked sensory aspects of the raw and cooked patties. Raw samples were evaluated based on appearance, color, odor, and texture. The cooked samples were checked for odor and taste.

3.83 Sensory Evaluation in the Restaurant

When ground beef patties are delivered to the restaurant, a case or bag count is verified against the invoice. The product's temperature, weight, sensory condition or the sensory condition of the delivery truck are not checked. A visual check of the cooked and assembled ground beef patty sandwich is normally performed before the menu item is served to the customer.

Periodically, a field inspector from the commissary inspects the individual restaurants using a Standards of Performance report which was developed by the commissary management. This once-a-month inspection involves an evaluation of the cooked ground beef sandwich based on sight only. In addition, the restaurant's dining room and staff are periodically evaluated using a Service Instructor's Report.

This latter report form does not cover a sensory evaluation of the ground beef sandwich.

CHAPTER 4

RESULTS

Hazard analysis is a series of activities focused on an in-depth study of the production process for a food product. Due to the preventive purpose of hazard analysis, the investigator examines the system for both the actual presence of, and the possibility for, unacceptable time-temperature combinations, potentially hazardous food products, pathogenic microorganisms, chemical or physical risks, unacceptable employee practices and hazardous environmental conditions. After the actual and potential hazards are explored, management is charged with the responsibility of developing and maintaining policies, procedures, standards and routines designed to minimize these risks.

4.1 Process Flow Diagram

The thrust of a process flow diagram is to provide a vehicle for visualizing the sequence of producing a product and identifying associated hazards. Prior to its construction, the process must be observed during actual operation to determine the flow steps and associated hazards. The second step is an information-gathering phase, consisting of questions and answers. The best sources for this information are management and the employees directly involved

with producing the product. Once the process flow diagram is constructed, it only needs to be modified to accommodate changes in the process, ingredients, or equipment.

The commissary serving as the basis of this research was visited on five occasions to observe and record the process flow of the ground beef patty under investigation. In addition, a company-owned restaurant located approximately 100 miles from the commissary was studied on two separate dates to determine the product flow in the restaurant. Several managers, supervisors and employees were interviewed to obtain information about the food product under investigation. The process flow diagram was constructed on the basis of these discussions and observations.

The complete process flow diagram for the production of the ground beef patty sandwich in this commissary food-service system is presented in Figure 4.100. All operations or process steps performed on the principal ingredient are shown as boxes connected by arrows which indicate the product flow. Items appearing to the left of the operations signify the addition of ingredients or supplies. Items appearing to the right of the operations represent either waste or the tests and inspections presently performed on the product at that step.

Operations beginning with purchase through assemble/load take place in the commissary. The products are then transported to the restaurant aboard company-owned trucks. After transport, the remaining operations in the process

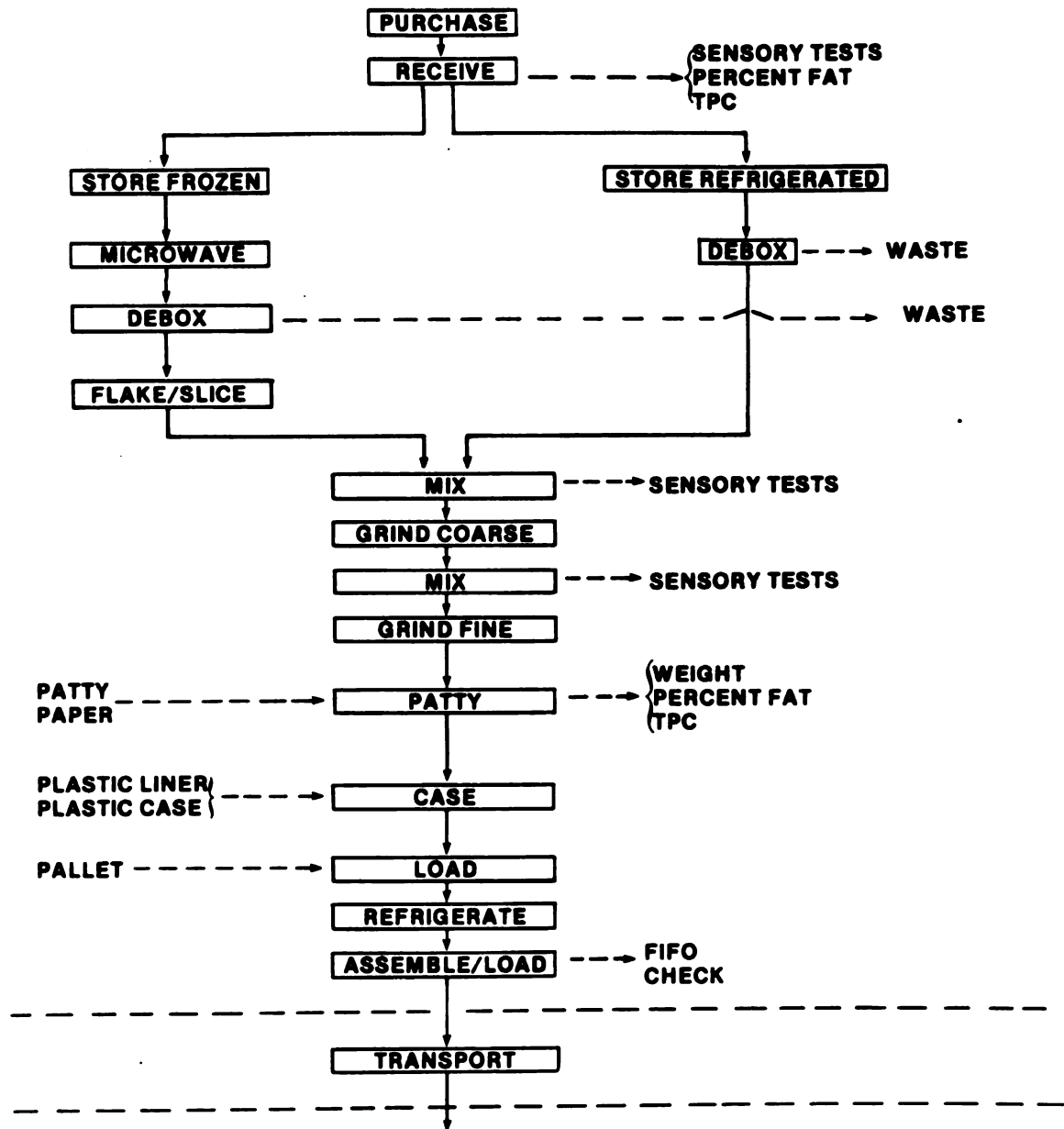


FIGURE 4.100 COMPLETE PROCESS FLOW DIAGRAM FOR GROUND BEEF PATTY SANDWICH PRODUCTION IN A COMMISSARY FOODSERVICE SYSTEM

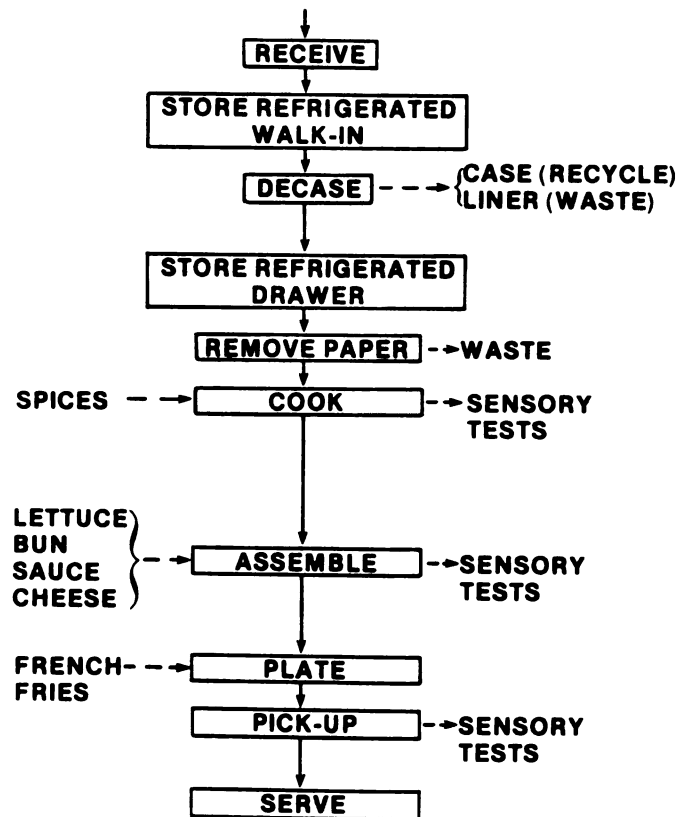


FIGURE 4.100 (CONT'D.)

flow diagram occur in the restaurant. The critical control points associated with the process flow diagram were identified in Table 3.130.

4.2 Commissary Process Flow Operations

The commissary produces approximately 17 tons per week of the ground beef patties investigated in this research. This amount represents over 55 percent of the total annual ground beef production by the commissary. Annually, this commissary foodservice system produces and sells over 1,500 tons of ground beef in three different forms.

4.21 Purchase

The fresh and frozen boneless beef and beef plates are purchased from as many as eight domestic and foreign suppliers. Suppliers quote prices to the commissary purchasing agent based on verbal specifications of what is desired. No written standard purchase specifications are used for these raw materials. The beef plates are United States Department of Agriculture (USDA) choice grade and are added to the patties for flavor. The boneless beef is USDA utility grade. Frozen beef is purchased less frequently than fresh beef.

4.22 Receive

The number of packages of beef products delivered to the commissary are counted and the figure is compared to that stated on the supplier's invoice. Prior to delivery by common carrier or the supplier's truck, a purchase order is sent to the receiving department indicating the item to be

delivered, when, and the amount. The fresh meat is delivered in a 2,000-pound container, whereas the frozen beef is received in 60-pound boxes. Neither the receiving department nor the commissary lab ever spot-checks the weights of the meat being delivered.

Meat delivered to the commissary has been inspected previously by the USDA and graded and certified as being wholesome. The meat from Australia has also been inspected by the Australian government. No inspections of the delivery trucks are performed by commissary personnel. Periodically, the lab staff evaluates six to ten boxes of frozen meat that are "randomly" (i.e., subjectively, not statistically) chosen. The evaluation covers TPC, percent fat, and physical defects (e.g., odor, color and dehydration). Depending on availability and workload of lab personnel, similar analyses of fresh meat may be performed. When time constraints surface, however, this receiving check is classified as a low priority item in relation to tests conducted on products produced in-house (e.g., ground beef patties).

4.23 Store Frozen, Store Refrigerated

Depending on the product's state when delivered, the meat is stored either frozen or chilled. Each pallet of frozen beef has six levels with five boxes per level, for a total of 1,800 pounds. These pallets are stored in a walk-in freezer with representative temperatures presented in Table 4.230. The 2,000-pound containers of beef are stored in the walk-in refrigerator with representative

TABLE 4.230 AMBIENT TEMPERATURES OF RAW BEEF AND
GROUND BEEF PATTY STORAGE AREAS IN
THE COMMISSARY AND RESTAURANT

LOCATION	TEMPERATURE, °F					STANDARD DEVIATION
	9/4/80	9/25/80	9/29/80	10/6/80	AVERAGE	
Commissary Freezer	-12	-	-8	0	-6.7	6.1
Commissary Refrigerator	38	-	30	36	34.7	4.2
Restaurant Walk-In Refrigerator	38	30	34	-	34.0	4.0
Restaurant Refrigerated Drawer	42	32	38	-	37.3	5.0

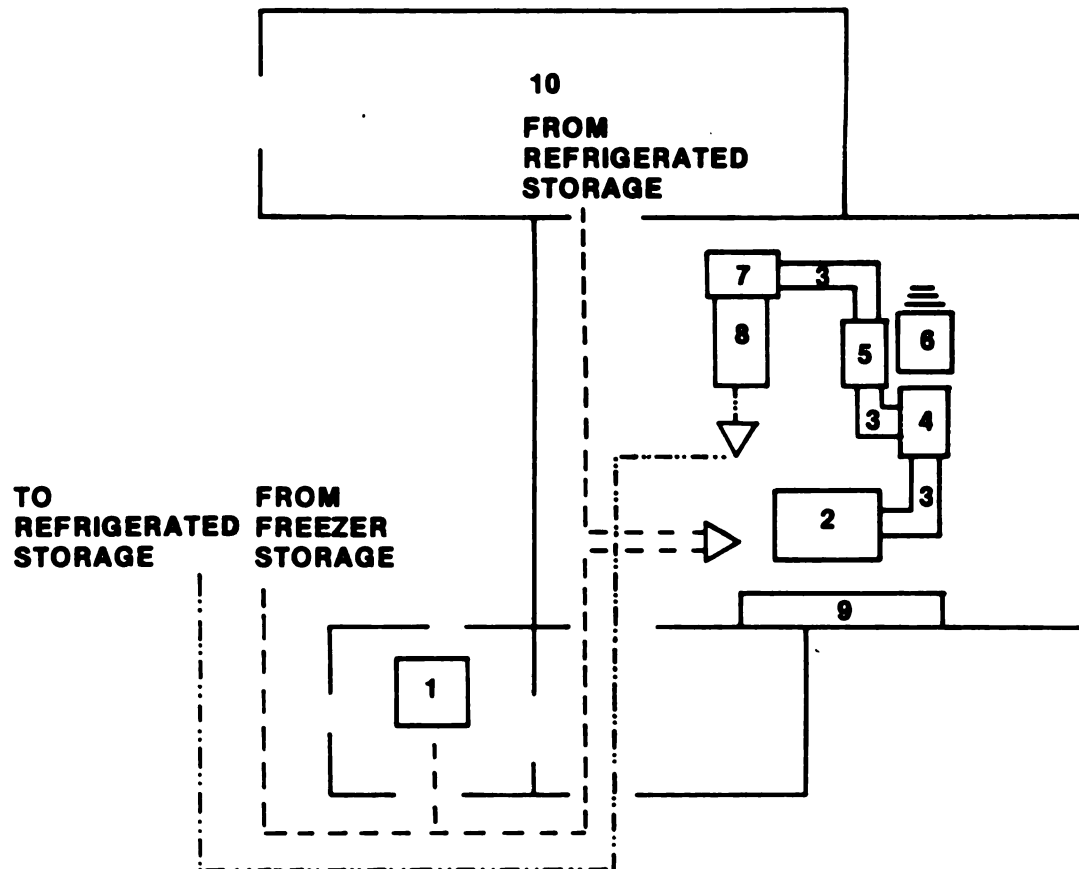
temperatures presented in Table 4.230.

4.24 Microwave, Debox, Flake/Slice

On production days, the frozen and fresh beef is delivered to the commissary meat room for processing by a crew consisting of five workers and the meat room supervisor. A plan view of the commissary meat room is presented in Figure 4.240. Prior to grinding, the frozen boxes of meat are tempered in a Raytheon microwave oven for about ten minutes to raise the product temperature to between 26° to 28°F (-3° to -2°C). This operation is necessary in order to flake and slice the frozen beef without damaging the Hydraflaker blades. After microwaving, the frozen beef is deboxed and flaked/sliced. The fresh beef is deboxed and mixed with the frozen beef. This mixing takes place in hopper number one.

4.25 Mix, Grind

No written formula exists for the production of a batch of ground beef patties. The beef mixture is ground coarse and then mixed in hopper number two. An individual, the batch master, who has worked in the commissary meat room for 15 years, performs a sensory inspection from the raised platform during the mixing operations. This inspection is based on experience, sight, and touch. After the second mixing operation, the beef is ground fine and travels via a conveyor to the Formax patty machine hopper.

**KEY**

- 1. RAYTHEON MICROWAVE
- 2. HYDRAUFLAKER
- 3. CONVEYOR
- 4. HOPPER #1
- 5. HOPPER #2
- 6. RAISED PLATFORM

- 7. FORMAX HOPPER
- 8. FORMAX PATTY MACHINE
- 9. WORK TABLE
- 10. REFRIGERATED STORAGE
- RAW PRODUCT FLOW
- .-.- GROUND BEEF PATTY FLOW

FIGURE 4.240 PLAN VIEW OF COMMISSARY MEAT ROOM
ILLUSTRATING RAW PRODUCT AND
GROUND BEEF PATTY FLOW
(NOT DRAWN TO SCALE)

4.26 Patty, Case, Load

The Formax patty machine produces four round ground beef patties at a time, one from each of its four position (die) locations, at a rate of approximately 200 patties every minute. The machine automatically delivers waxed patty paper to separate each patty, and stacks the patties in stacks of 14 patties. Then the machine's conveyor belt advances and begins a new stack. The patties are stacked manually into plastic bags placed in plastic lugs holding approximately 25 pounds when filled. The plastic lugs are hand-loaded on pallets and stored in the commissary walk-in refrigeration unit.

4.27 Refrigerate

Once processed, the beef is held at refrigerated temperatures. The patties that were processed most recently are stored on shelves in the walk-in. Any patties remaining from a previous day's production run are stored on pallets on the floor of the walk-in. This system of stock rotation helps guarantee a first-in, first-out (FIFO) inventory system.

4.28 Assemble/Load

When the restaurant places an order with the commissary for ground beef patties, an individual from the loading crew fills the order based upon a computerized print-out. The items ordered for each restaurant are placed in one or more mobile cages. Each cage is checked for product count prior to loading.

4.29 Transport

The ground beef patties are transported to the restaurant in refrigerated, company-owned trucks. No monitoring of the truck's storage environment is done on a regular basis. Company trucks deliver commissary products to the restaurants two to four times per week, depending on the geographical location of the restaurant.

4.3 Restaurant Process Flow Operations

The company-owned restaurant investigated in this study is located approximately 100 miles from the commissary. This 130-seat restaurant does an average total weekly food and beverage volume of \$10,000. With average weekly sales of \$10,000, the restaurant orders approximately six 25-pound cases of ground beef patties per week, an amount that represents over 50 percent of the total weight of all ground beef items ordered in a typical week by this restaurant.

Orders for food, beverages, and non-food supplies are placed with the commissary three times per week. The inventory code of each item, together with the amount to be delivered, is entered into the commissary's computer via a touch-tone telephone. The order is delivered two days after it is placed.

4.31 Receive

All commissary products are delivered to the restaurant by a company-owned truck. The restaurant manager, assistant manager, or a trained employee receives all deliveries and verifies the case count against the amount

charged on the invoice. No checks of the delivery truck, product weights, or temperatures are made, nor are sensory evaluations of the delivered products performed.

4.32 Store Refrigerated Walk-in

After receipt, the ground beef patties are stored in a refrigerated walk-in cooler with representative temperatures reported in Table 4.230. The FIFO inventory system is maintained by placing the older items on top or to the front of the cooler shelf. However, there is no dating or tagging of ground beef patties.

4.33 Decase, Store Refrigerated Drawer

Each morning, the line cook stocks the ground beef patties in a refrigerated drawer located under the bank of cooking equipment. Based on par inventory figures, the number of patties forecasted to be sold that day are de-cased and placed in the refrigerated drawer. This forecasted number is determined by management after considering both historical trends and other relevant information. The temperatures of the refrigerated drawer are listed in Table 4.230.

4.34 Remove Paper, Cook

After the customer's order is taken by the waitress, it is verbally "called in" to the cook via a public address system. The waitress also writes up the order and places it on a revolving spindle so the cook can refer to the order. Since all ground beef items are prepared to order, the cook removes the paper from two patties and places

these on the grill for each double-deck ground beef sandwich ordered. Immediately, the cook places a double decker bun in the bun toaster.

The grill's temperature is set at 325°F (163°C) as specified in the organization's standard recipe for preparing this menu item. Patties are turned when juice appears on the top. The cook is instructed to turn each patty only once and not mash the patties or drain the juice. Each patty is seasoned with a special blend of spices before being removed from the grill.

4.35 Assemble, Plate

After the bun is toasted, lettuce, one slice of cheese, and a special sauce are placed on the bun. The cooked patties are added and the double-deck sandwich is assembled. The cook has been instructed to build the sandwich straight and wrap it carefully if a take-out order is being assembled. If the customer ordered a combination plate, french fries are also cooked and placed on the same plate as the double-deck sandwich.

4.36 Pick-up, Serve

Once plated, the food is placed on the pick-up shelf. The waitress call button is pushed by the cook to indicate that the order is ready to be served. The waitress picks up the order and serves it to the customer along with any additional food items ordered.

The manager of this restaurant emphasized that he or his assistant makes an effort to visually check each menu

item before it is served. Since it is impossible for this inspection to occur on an on-going basis during busy periods, it is necessary to rely on the judgment of employees. The only way for this system of inspection to be effective is to train employees to be cognizant of the criteria used for sensory evaluations of food products.

4.4 The Pareto Analysis and Results

The Pareto analysis is a rational tool capable of separating the commissary meat room swab sites into "vital few" and "trivial many" categories. This tool permits the quality assurance staff to maximize their efforts in monitoring equipment sanitation. The Total Plate Counts (TPCs) and meat contact scores (Table 3.240) were used to develop a scheme to focus the attention of the sanitation crew on the "vital few" locations in the meat room. The method of priority rankings automatically rearranged the priorities to focus attention on the remaining sensitive swab sites. This modified scheme improved the overall sanitation effort.

4.41 Calculation of Priority Rankings

The priority ranking procedure was instituted for a six-week period (February 17, 1981 to March 31, 1981). During this study, the number of swab tests per week was increased from eight to a total of twelve, six swabs each on Tuesdays and Thursdays. The lab staff did not actually count the number of colonies on each of the incubated plates, but simply placed each result into one of three categories: 3 (<1 to 1000 colonies), 2 (1001 to <TNTC) or 1 (TNTC).

This ranking for each of the six swab sites was entered on a priority record designed specifically for this study (see Table 4.410).

The record contains the following information: swab sites, meat contact scores (from Table 3.240), the starting (S) TPC scores (from Table 3.240), and the priority rankings. The priority rankings were based on a moving average of the two most recent periods in which a swab was taken of the individual swab site. The moving average TPC was calculated from the two most recent TPC scores for each swab site. The priority ranking was calculated by multiplying the moving average TPC by the meat contact score for that swab site. This figure is the revised priority ranking and it was entered in the appropriate priority ranking column on the priority record.

The lab staff member selected the six locations to swab during the next series of swab tests by choosing the six lowest priority ranking numbers in the previous period. A low number indicated a high priority, that is, a location that needs more effective cleaning and sanitizing. In the event of a tie, such swab sites were sampled in rotation. Tuesday's plates were evaluated and the priority rankings recalculated before Thursday's swabs were taken. Thursday's plates were evaluated and the priority rankings recalculated before Tuesday's swabs were taken.

Once the TPC scores were determined, they were entered on the sanitation crew's alert sheet, which was posted

TABLE 4.410 PRIORITY RECORD FOR MONITORING
THE SANITATION EFFORTS IN THE
COMMISSARY MEAT ROOM

SWAB SITE	MEAT CONTACT SCORE ¹	TPC SCORE ¹	PRIORITY RANKING
		<u>SAMPLING DATE</u> S ²	<u>EVALUATION DATE</u>

¹See Table 3.240

²Average of the historical TPCs from February 1980 through August 1980.

outside of the commissary lab (see Table 4.411). The sanitation crew leader was alerted to the TPC scores so that the sanitation crew's efforts could be focused on the most sensitive locations. The completed priority record is presented in Table 4.412, while the completed alert sheet is presented in Table 4.413.

By calculating the total of the priority rankings on each date, it was possible to evaluate the success of this program. The maximum score attainable is 123 and the lowest possible score is 41. The total was initially 69.5 and it increased to 89.5 at the end of the six-week study. Since higher total values indicate a decrease in TPC scores, it can be concluded that the modified scheme was effective in reducing the amount of contamination of ground beef due to contact with meat room equipment.

4.5 Analysis of Patty Weights

The commissary presently produces the ground beef patties from a combination of fresh and frozen boneless beef and beef plates. The product specifications are established at 45.4 grams $\pm$ 1 gram (ten patties to a pound of ground beef). These round patties are produced by the Formax patty machine at a rate of approximately 200 per minute.

4.51 Covariant Analysis

The covariant analysis was run on all 760 patty weights (Appendix F) using the GENSTAT V program. The covariable was pressure in pounds per square inch (psi) which

TABLE 4.411 ALERT SHEET FOR TPC SCORES
USED TO INFORM THE COM-
MISSARY SANITATION CREW

SWAB SITE	TPC SCORE ¹
	SAMPLING DATE
	S ²
Hydrauflaker table	1
Hydrauflaker blade	1
Conveyor #1 belt	1
Conveyor #1 side	3
Conveyor #2 belt	1
Conveyor #1 top	1
Hopper #1	3
Grinder #1 throat	1
Grinder auger	1
Grinder blade	3
Hopper #2 cover	1
Grinder #2 throat	2
Formax hopper	2
Formax plates	1
Formax auger	3
Formax conveyor belt	1
Formax plunger	3
Paper chute	1
Shovel	1
White tub	1
Sst tub	2
Barrel	1
Scoop	3
Steak cutting knives	2

¹TPC Score: 3 (<1 to 1000), 2 (1001 to <TNTC),
1 (TNTC).

²Average of the historical TPCs from February
1980 through August 1980.

[illegible]

TABLE 4.412 (continued)

SWAB SITE	PRIORITY RANKING											
	2/19	2/24	2/26	3/3	3/5	3/10	3/12	3/17	3/19	3/24	3/26	3/31
Hydraflaker table	2	3	3	3	3		3	3	3	3	3	3
Hydraflaker blade	1.5	2.5	2.5	2.5	2.5	3	3	2	1	1	1	2
Conveyor #1 belt	2	2	2	1.5	1.5	2	2	1	2	3	3	3
Conveyor #1 side	6	6	6	6	6	6	6	6	6	6	6	6
Conveyor #2 belt	1	1	1	1	1	1	1	1	2	3	3	3
Conveyor #1 top	1	2	2	1.5	1.5	1.5	1.5	1	2	3	3	3
Hopper #1	3	3	3	3	3	3	3	3	3	3	3	3
Grinder #1 throat	2	3	3	3	3	3	3	3	3	3	3	3
Grinder auger	1	2	2.5	2.5	2.5	2.5	3	3	3	3	3	3
Grinder blade	3	3	3	3	3	3	3	3	3	3	3	3
Hopper #2 cover	3	3	3	3	3	3	3	3	3	3	3	3
Grinder #2 throat	2	2	2.5	2.5	2.5	2.5	2.5	3	3	3	3	4.5
Formax hopper	4	4	4	4	4	4	4	4	4	4	4	4
Formax plates	2	2	2	2	4	4	4	4	4	4	4	4
Formax auger	3	3	3	3	3	3	3	3	2	2	3	3
Formax conveyor belt	3	3	3	3	3	3	3	3	6	6	6	6
Formax plunger	6	6	6	6	6	6	6	6	6	6	6	6
Paper chute	3	3	3	3	3	3	3	3	3	3	3	3
Shovel	2	2	2	2	4	4	4	4	4	4	4	4
White tub	2	2	2	2	3	3	3	3	3	3	3	3
Sst tub	4	4	4	4	4	4	4	4	4	4	4	4
Barrel	3	3	3	3	3	3	3	3	3	3	3	3
Scoop	6	6	6	6	6	6	6	6	6	6	6	6
Steak cutting knives	4	4	4	4	4	4	4	4	4	4	4	4
Total	69.5	74.5	75.5	74.5	79.5	80.5	81	79	83	86	86	89.5

TABLE 4.413 COMPLETED ALERT SHEET FOR TPC SCORES USED TO
INFORM THE COMMISSARY SANITATION CREW

SWAB SITE	TPC SCORE												
	S	2/17	2/19	2/24	2/26	3/3	3/5	3/10	3/12	3/17	3/19	3/24	3/26
Hydraflaker table	1	3	3	-	-	-	-	-	-	-	-	-	-
Hydraflaker blade	1	2	3	-	-	-	3	-	1	1	1	1	3
Conveyor #1 belt	1	3	-	1	2	1	3	1	1	3	3	-	-
Conveyor #1 side	3	-	-	-	-	-	-	-	-	-	-	-	-
Conveyor #2 belt	1	1	1	1	1	1	1	1	1	3	3	-	-
Conveyor #1 top	1	1	3	1	2	1	2	1	1	3	3	-	-
Hopper #1	3	-	-	-	-	-	-	-	3	-	-	-	3
Grinder #1 throat	1	3	3	-	-	-	-	-	-	-	-	3	-
Grinder auger	1	-	3	2	-	-	3	3	-	-	-	-	-
Grinder blade	3	-	-	-	-	-	-	3	-	-	-	-	-
Hopper #2 cover	1	-	-	-	-	-	-	-	-	-	1	1	2
Grinder #2 throat	2	-	-	3	-	-	2	3	3	-	-	-	3
Formax hopper	2	-	-	-	-	-	-	-	-	-	-	-	-
Formax plates	1	-	-	1	1	3	-	-	-	-	-	-	-
Formax auger	3	-	-	-	-	-	-	-	-	1	3	3	3
Formax conveyor belt	1	-	-	-	-	-	-	-	-	3	-	-	-
Formax plunger	3	-	-	-	-	-	-	-	-	-	-	-	-
Paper chute	1	-	-	-	-	-	-	-	-	-	-	1	-
Shovel	1	-	-	-	1	3	-	-	-	-	-	-	-
White tub	1	-	-	-	1	2	-	-	-	-	-	-	-
Sst tub	2	-	-	-	-	-	-	-	-	-	-	1	3
Barrel	1	-	-	-	-	-	-	-	-	-	-	-	-
Scoop	3	-	-	-	-	-	-	-	-	-	-	-	-
Steak cutting knives	2	-	-	-	-	-	-	-	-	-	-	-	-

¹TPC Score: 3 (<1 to 1000), 2 (1001 to <TNTC), 1 (TNTC)

was read from the Formax patty machine pressure indicator dial. The GENSTAT V program adjusted these data to an average psi to facilitate the analysis of the other independent effects. The model used for the analysis of covariance was:

$$\text{weight} = \mu + \text{batch} + \text{sample within batch} + \text{position} + \text{replicate} + \text{position by replicate} + \beta \times \text{psi} + \text{error}$$

The results of the analysis of variance, adjusted for the covariate psi, are presented in Table 4.510.

The covariate across batches indicated no significant difference ($\alpha = .05$) for batch effects. This suggests that psi cannot explain differences between batches. Having adjusted for psi, batch differences existed as evidenced by the F-statistic of 141.0. These differences may be explained by different production dates, different product or equipment temperatures, different batch formulations of fat-to-lean or frozen-to-thawed meat, or any other possible differences. Any corollary effects, or undefined or unmeasured effects, synonymous with batch could be possible sources of batch differences.

The F-statistic for position is significant ($\alpha = .05$). Through observation, it was noted that position number two varied more than the other three positions. The precise reason that position number two was the most variable cannot be explained on the basis of this analysis. Most of the defined differences were in position. The position by

TABLE 4.510 ANALYSIS OF VARIANCE OF PATTY
WEIGHTS PRODUCED IN A COMMIS-
SARY FOODSERVICE SYSTEM
(n=760)

SOURCE	df	SUM OF SQUARES	MEAN SQUARE	F
Covariates across batches	1	15.0286	15.0286	1.1
Batch	11	151.1167	13.7379	141.0
Sample/Batch	6	5.1784	0.8631	8.9
Position	3	0.8548	0.2849	2.9
Replicate	9	1.1341	0.1260	1.3
Position by Replicate	27	1.5644	0.0579	0.6
Covariates within batches	1	0.0489	0.0489	0.5
Residual	701	68.3081	0.0974	
Grand Total	759	243.2340		

replicate interaction is not significant ($\alpha = .05$). This says that the position ranking remained constant among replicates or the replicate ranks were identical for position. Recall that the ten replicates are made within twelve seconds.

4.52 Bonferroni t-Test

A Bonferroni t-test is utilized when it is not possible to formulate contrasts prior to the experiment due to insufficient information (Gill, 1978). Two schools of thought exist regarding the application of Bonferroni t-tests. One group holds that if the F-statistic is not significant, there is no reason to look for individual contrasts. The other group believes that whenever there are a relatively large number of degrees of freedom, differences could exist regardless of the size of the F-statistic. The Bonferroni t-test does not presume a prior significant result for the overall test of mean differences because the total probability of a Type I error (α) is split among the set of designed comparisons (Gill, 1978).

The Bonferroni t-test statistics were calculated utilizing the procedure outlined by Gill (1978). The mean values for both positions and replicates were taken from Table 4.520. In the case of positions, the calculation was based on the largest difference (i.e., positions 3 and 4). For replicates, the largest difference was between replicates 1 and 10.

Even though the F-statistic is significant for

TABLE 4.520 AVERAGE WEIGHTS (IN GRAMS) OF
GROUND BEEF PATTIES PRODUCED
IN A COMMISSARY FOODSERVICE
SYSTEM (n=760)

POSITION OR REPLICATE NUMBER	AVERAGE WEIGHT, GRAMS	
	POSITION (n=190)	REPLICATE (n=76)
1	44.328	44.425
2	44.354	44.379
3	44.308	44.350
4	44.398	44.377
5		44.363
6		44.326
7		44.331
8		44.300
9		44.328
10		44.290

positions ($\alpha = .05$), the Bonferroni t-test of all possible positions failed to find where the difference existed. For replicates, there was no significant difference although replicate number 1 was different than replicate number 10. No trends could be identified for replicates, using the Bonferroni t-test.

The F-statistic showed that positions were significant ($\alpha = .05$) and nothing more. Apparently, there was unequal pressure exerted by the Formax patty machine in the four positions or possibly the mechanism delivering the meat did it differently for the different positions. Since there was no method for testing the differences except all possible differences, it was not possible to statistically point to where the differences existed. There may not be a large enough difference between 125 psi and 150 psi to significantly influence the patty weights with the pressure setting. A visual examination of the Formax patty machine's plate containing the four position locations revealed no noticeable differences. This intraocular test leads one to conclude that there is no reason to expect differences between the positions.

One of the problems with multiple comparisons is that one gives up power ($1 - \beta$) to maintain integrity (α). That being true, one needs an a priori feeling as to where one might be searching for the differences. Without these pre-conceived assumptions, the only alternative is to perform an a posteriori test on all possible contrasts.

4.6 Process Capability Analysis

A process capability analysis was performed on the 760 patty weights. The thrust of a process capability analysis is to provide management with information with which to decide whether it is economically feasible to reduce the variability and increase conformance to the established tolerances. The commissary specification and tolerance for patty weight is 45.4 grams $\pm$ 1 gram. The study determined where the process was centered and whether the process was inherently capable of meeting the specified tolerance.

4.61 Process Capability Calculations

The process capability data were collected and tabulated into 4 (n) groups with 190 (k) subgroups for a total of 760 net patty weights. The mean, $\bar{x}$, and the range, R , of each 4-unit subgroup was computed and recorded. These data are presented in Appendix F.

The average range, $\bar{R}$, was calculated by taking the sum of the 190 ranges and dividing by 190. The initial $\bar{R}$ equaled 0.61 grams. The upper and lower 3-sigma limits of the range were computed using $\bar{R}$ and the appropriate D_3 and D_4 factors and formulas from Table 4.610. The observed ranges were then examined and any outside of the 3-sigma limits were discarded.

The average range and new limits were then recalculated and the ranges reexamined to determine which were outside of the new limits. This process was repeated

TABLE 4.610 FACTORS FOR CHECKING FOR THE
 PRESENCE OF CONTROL, GIVEN
 $\bar{R}$ (3-SIGMA LIMITS)¹

NUMBER OF UNITS, n	FACTOR		
	d_2	D_3	D_4
3	1.693	0	2.58
4	2.059	0	2.28
5	2.326	0	2.11
6	2.534	0	2.00
8	2.847	0.14	1.86
10	3.078	0.22	1.78

Formulas:

$$URL = D_4 \times \bar{R}$$

$$LRL = D_3 \times \bar{R}$$

$$s_{est} = \frac{\bar{R}}{d_2}$$

¹ASTM (1951).

until all of the remaining ranges fell within the limits last calculated. In total, eleven ranges were eliminated: two from August 26 (batch 1), six from September 4 (batch 1), and three from September 29 (batch 1).

The final $\bar{R}$ was 0.552 grams, while the final URL and LRL were 1.26 grams and 0 grams, respectively. The standard deviation was then estimated from the final $\bar{R}$ and appropriate d_2 factor and formula from Table 4.610. The estimated standard deviation, s_{est} , was calculated to be 0.268 grams.

The observed average value of the patty weights $\bar{\bar{X}}$, was then calculated from the sum of the individual means. This grand average was determined to be 44.32 grams. Next, the frequency and cumulative frequency distributions were constructed. The x_i 's were sorted and placed into suitable, equal-sized intervals. The number of intervals, j , was calculated using Sturgis's rule as follows:

$$j = 1 + 3.3 \log N$$

The number of intervals, j , equaled 10.504. The intervals covered a span of the natural limits of the process, six standard deviations, or 1.608 grams. The interval size was rounded to 0.15 grams to give it the same precision as the original data.

Next, the interval boundaries were established. To find the starting point, one-half of the interval size, 0.15 grams, was subtracted from the grand mean, 44.32 grams. To find the boundaries of the smaller values of x_i , the value

of the interval size was subtracted, successively, from the starting point, 44.245 grams. To find the boundaries of the larger values of x_i , the value of the interval size was added, successively, to the starting point. A sufficient number of intervals was calculated to cover all values of x_i .

4.62 Frequency Histogram and Cumulative Percentage Plot

Table 4.620 presents the percentage and cumulative percentage of x_i 's in each interval. The frequency (percentage) histogram and the cumulative percentage (normal probability) plot were constructed and analyzed. Figure 4.620 presents the frequency histogram, while the cumulative percentage plot is displayed in Figure 4.621. The $\bar{R}$ chart of net patty weights is presented in Figure 4.622. This chart illustrates both upper and lower range limits for the patty weights.

4.7 Analysis of Patty Fat Content

The commissary's stated objective is to produce a patty with a composition of 22 percent fat and 78 percent lean. Because fat is less dense than muscle tissue, the effect of varying the fat content in the patty may influence patty weight. In addition, a higher fat content may affect the flavor of the cooked patty. Beyond that, economic factors must be considered because muscle tissue is usually more expensive than fat.

4.71 Percent Fat in the Pretest vs. Percent Fat in the Patty

The pretest fat content was determined using a variation of the Babcock procedure after the initial batch of fresh and frozen boneless beef and beef plates was ground.

TABLE 4.620 NUMBER, PERCENTAGE, AND CUMULATIVE
PERCENTAGE OF x_i 's IN EACH INTER-
VAL FOR THE PROCESS CAPABILITY
STUDY OF GROUND BEEF PATTY
WEIGHTS (n=760)

INTERVALS		NO. OF ITEMS IN INTERVAL	PERCENTAGE IN THE INTERVAL	CUMULATIVE PERCENTAGE IN THE INTERVAL
FROM	TO			
41.845	41.995	1	0.13	0.13
41.995	42.145	-	-	0.13
42.145	42.295	-	-	0.13
42.295	42.445	-	-	0.13
42.445	42.595	-	-	0.13
42.595	42.745	3	0.40	0.53
42.745	42.895	2	0.26	0.79
42.895	43.045	10	1.32	2.11
43.045	43.195	12	1.58	3.69
43.195	43.345	16	2.11	5.80
43.345	43.495	15	1.97	7.77
43.495	43.645	22	2.90	10.67
43.645	43.795	39	5.13	15.80
43.795	43.945	47	6.18	21.98
43.945	44.095	68	8.95	30.93
44.095	44.245	75	9.87	40.80
44.245	44.395	79	10.40	51.20
44.395	44.545	60	7.90	59.10
44.545	44.695	74	9.74	68.84
44.695	44.845	80	10.53	79.37
44.845	44.995	86	11.32	90.69
44.995	45.145	48	6.32	97.01
45.145	45.295	12	1.58	98.59
45.295	45.445	4	0.53	99.12
45.445	45.595	2	0.26	99.38
45.595	45.745	-	-	99.38
45.745	45.895	1	0.13	99.51
45.895	46.045	3	0.40	99.91
46.045	46.195	-	-	99.91
46.195	46.245	1	0.13	100.00

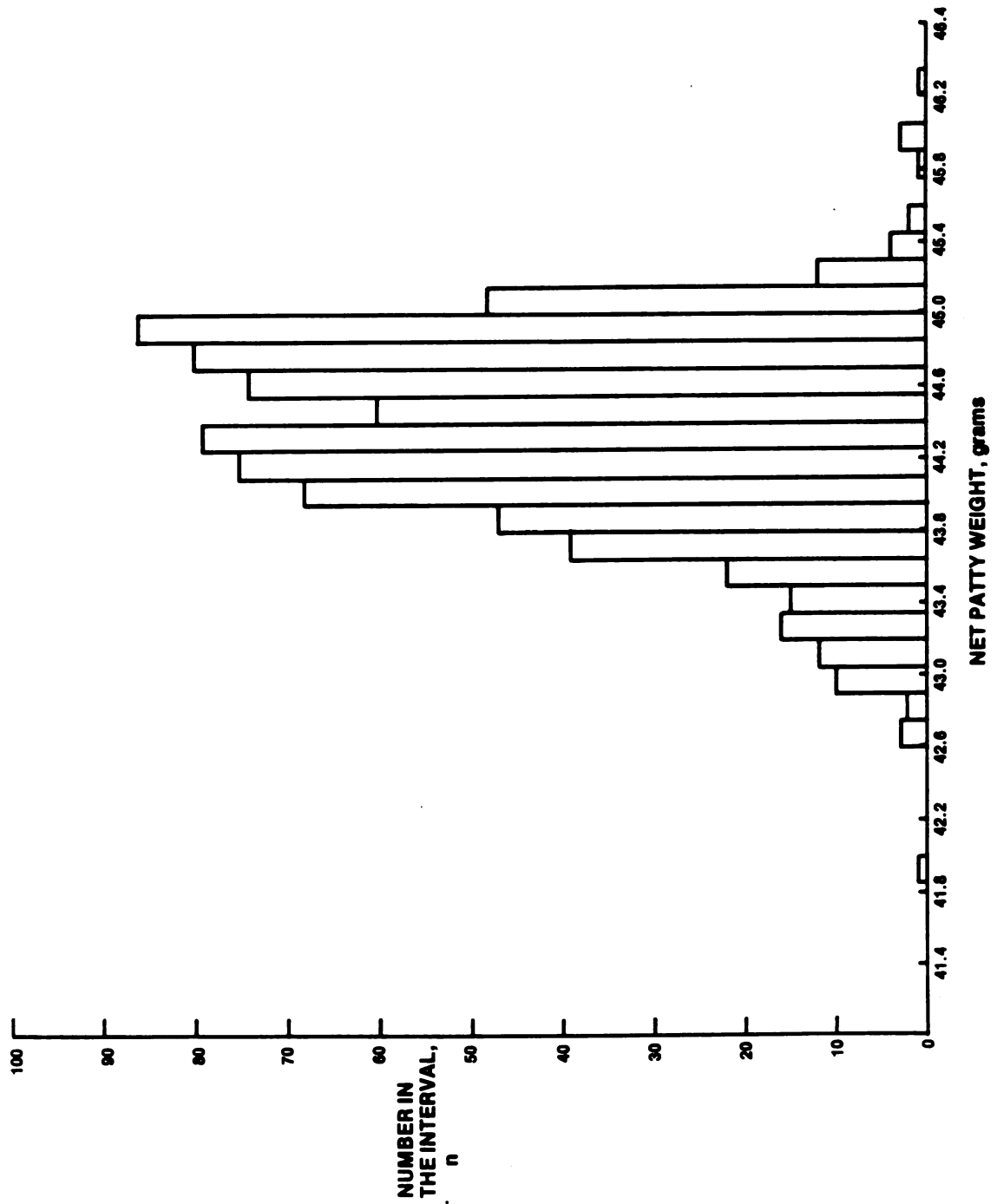


FIGURE 4.620 FREQUENCY HISTOGRAM OF GROUND BEEF PATTY WEIGHTS (n=760)

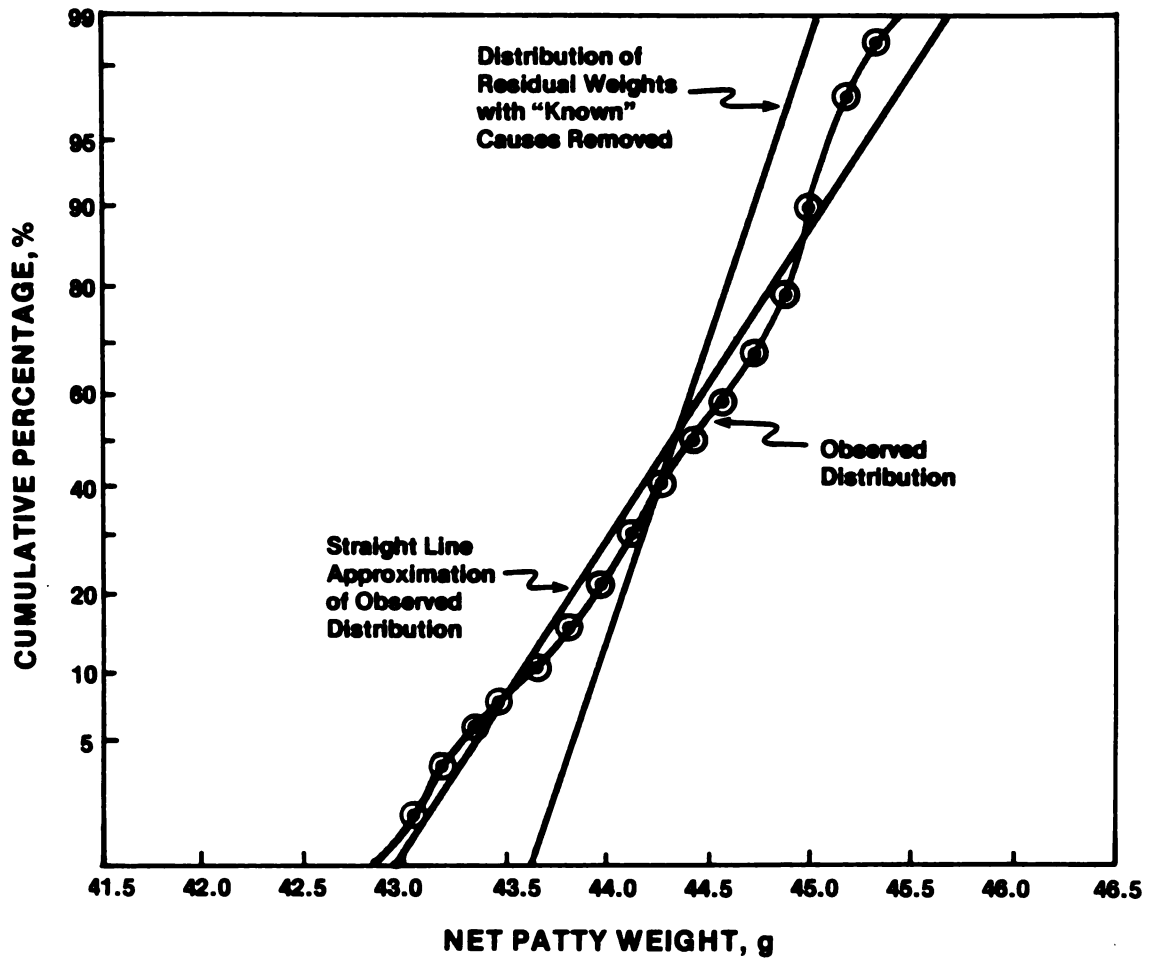
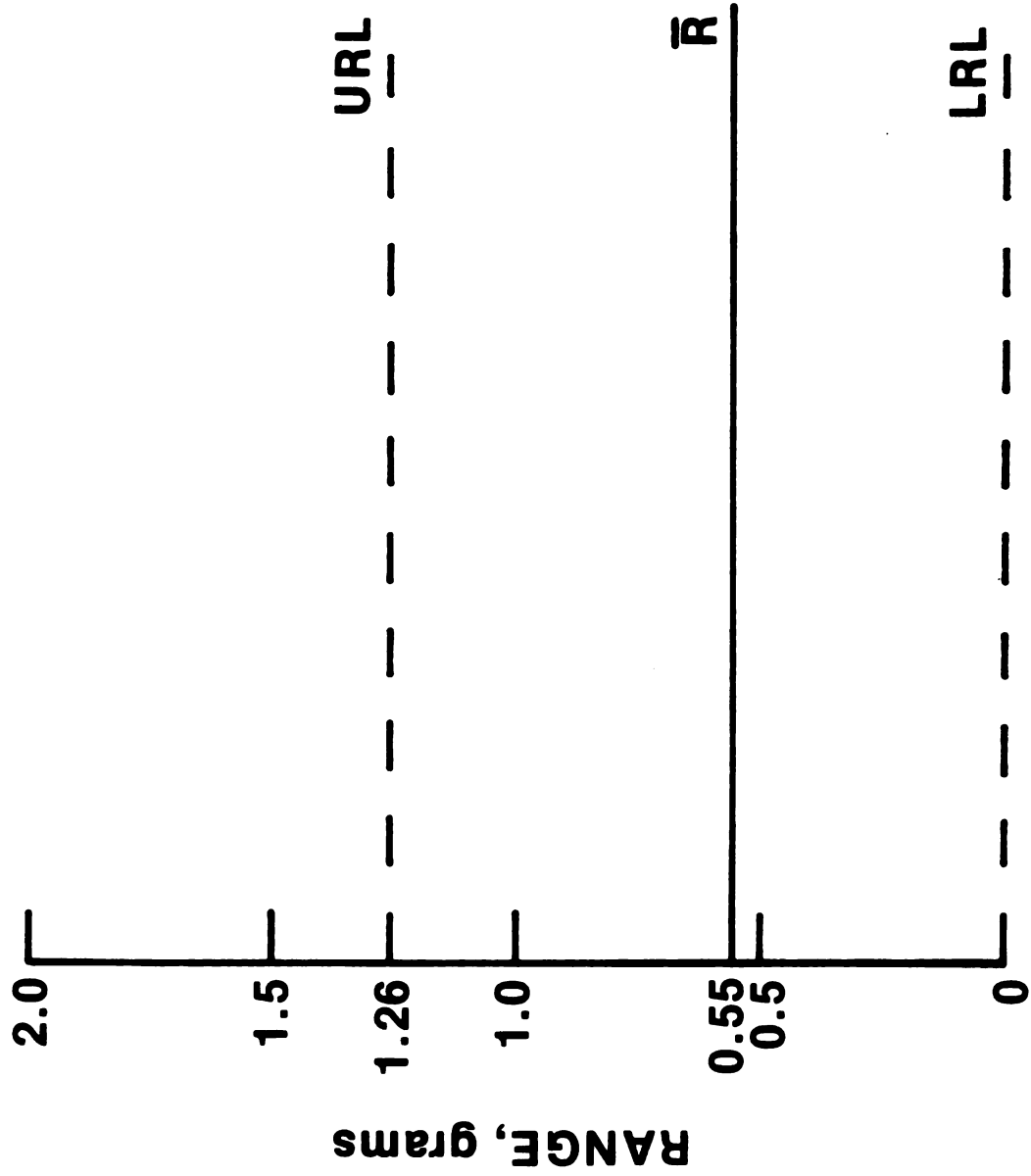


FIGURE 4.621 CUMULATIVE FREQUENCY PLOT OF GROUND BEEF NET PATTY WEIGHTS (n=760)

FIGURE 4.622 $\bar{R}$ CHART OF GROUND BEEF NET PATTY WEIGHTS

The sample was taken from the first batch processed by the meat room crew on each production day. The post test fat content was the average fat content of five or six ground beef patties delivered to the lab throughout the production run.

Thirty-four pairs of numbers from the commissary records, representing the percent fat in the pretest and the corresponding percent fat in the patty, were analyzed using the Interactive Data Analysis (IDA) program on the Hewlett Packard System. The IDA program uses least-squares linear regression to find the relationship, if any, between the independent variable (percent fat in the pretest) and the dependent variable (percent fat in the patty). The objective was to determine to what extent variation in the fat content of the finished patty is governed by the fat content in the pretest. These data are presented in Appendix C.

Initially, it must be determined whether a correlation between the pretest and post test exists and whether the relationship appears to be linear. The correlation coefficient, R , between the pretest and the post test was 0.65 which indicated that a possible causal relationship existed. A linear relationship appeared to exist when the scatter plot of the post test vs. the pretest was evaluated. Therefore, it appeared that regression may provide more information about this relationship.

After running the regression analysis, the residuals were checked to determine if their behavior adhered to the

fundamental assumptions of regression: independence, normality, and homoscedasticity. With respect to independence, the residuals were evaluated using the autocorrelation function. It appeared that only two to four percent of the error was attributable to the linear relationship, therefore, the errors are independent. In addition, the Studentized range coefficient of 4.579 ($n=34$) indicated that the residuals were normally distributed, although skewed slightly to the left. The assumption of homoscedasticity appears not to have been violated. A sequence plot of the residuals indicated that the variance was constant through time. A plot of the pretest versus the residuals and the post test versus the residuals indicated no abnormal variance behavior.

The equation for the regression line of this relationship is:

$$\text{post test \%} = 18.5\% + 0.21 \times (\text{pretest \%})$$

The t-test on the slope coefficient, b_1 , was 4.84. This value is greater than the critical t-test value of 2, therefore, b_1 is significantly different than zero with a 95 percent confidence level. The t-test on the y-intercept was 21.9. This value is also greater than the critical t-test value of 2, therefore, it is significantly different than zero with a 95 percent confidence level. The coefficient of determination, R^2 , measured the proportion of the variance in the post test which could be attributed to the pretest. The R^2 was 0.42, which indicated that only 42

percent of the variance in the post test was attributable to the linear relationship with the pretest.

In conclusion, approximately 60 percent of the influence on the percent fat in the post test was attributable to factors other than the percent fat in the pretest. The independent variable provided some information about the dependent variable, however, the R^2 and t-test values were relatively low. The y-intercept is much more important in describing the dependent variable. It appears that the pretest is not a very reliable predictor of the post test percent fat. There are either intervening variables or the relationship between the post test and the pretest was confounded by other factors.

4.72 The Percent Fat in the Pretest vs. Patty Weight

The IDA program was also used to determine whether or not the patty weight could be predicted from the percent fat in the pretest. The analysis of the 113 pairs of historical data points (see Appendix D) indicated a negative correlation, R , of -0.02 between percent fat in the pretest and patty weight. This negative correlation appears to show that, as the fat content increases, there is a slight decrease in patty weight. However, the relationship is not very strong. It appears safer to say that there is no causal relationship between the fat content and the patty weight.

4.8 Analysis of Microbiological Results

The commissary lab staff monitors the microbiological condition of incoming raw beef and ground beef patties.

The incoming fresh beef is checked less frequently than the incoming frozen beef. Microbiological samples of the finished ground beef patties are plated and incubated on the day which they are produced. No microbiological analysis is conducted on ground beef patties once they are placed in refrigerated storage, whether they are in the commissary or the restaurant.

4.81 Total Plate Counts

Total Plate Counts (TPCs) are utilized to evaluate the microbiological condition of the products received by and produced within the commissary. TPCs indicate the total number of living organisms in a sample with no clue as to the type of microbes. Once the TPCs are determined for a sample, the values are entered into the commissary lab notebook along with the product name or identification code and the date of analysis. Table 4.810 summarizes the TPC results from fresh and frozen incoming beef. The TPCs results from the lab notebook for ground beef patties are presented in Table 4.811. These values are representative of the past history. The averages and standard deviations of the results are reported in Table 4.812.

4.82 Sampling Plans

The International Commission on Microbiological Specifications for Food (ICMSF) has, among their recommended sampling plans for various groups of food, plans for frozen and chilled beef and frozen ground beef. Since it is well-known that bacterial populations can vary widely between subsamples,

TABLE 4.810 TOTAL PLATE COUNTS (TPCs) OF
FRESH AND FROZEN BONELESS
BEEF RECEIVED AT THE
COMMISSARY

DATE OF RECEIPT	CONDITION WHEN RECEIVED	TPC (COLONIES/GRAM)
April 15, 1980	Frozen	1.1×10^3
	"	1.4×10^6
	"	9.0×10^4
	"	3.0×10^5
	"	3.0×10^4
	"	1.2×10^5
	"	2.4×10^3
	"	6.0×10^5
	"	2.6×10^3
	"	2.5×10^3
May 8, 1980	Fresh	2.0×10^3
	"	1.8×10^4
May 9, 1980	Fresh	4.1×10^3
	"	4.0×10^2
May 13, 1980	Fresh	1.4×10^3
	"	1.8×10^4
May 23, 1980	Frozen	3.8×10^5
	"	4.1×10^3
	"	1.4×10^4
	"	1.1×10^3
	"	4.8×10^3
	"	1.8×10^3
	"	3.7×10^3
	"	5.3×10^4
	"	1.1×10^3
	"	8.8×10^4
May 29, 1980	Fresh	6.0×10^2
	"	2.7×10^2

TABLE 4.810 (CONT'D.)

DATE OF RECEIPT	CONDITION WHEN RECEIVED	TPC (COLONIES/GRAM)
June 3, 1980	Fresh	1.3×10^3
June 6, 1980	Fresh	5.1×10^4
June 9, 1980	Frozen	3.1×10^3
	"	1.8×10^4
	"	3.0×10^2
	"	1.0×10^4
	"	1.0×10^3
	"	6.0×10^2
	"	3.0×10^3
	"	8.0×10^4
	"	6.0×10^3
	"	1.4×10^4
June 20, 1980	Frozen	2.0×10^4
	"	4.0×10^4
	"	7.0×10^5

TABLE 4.811 AVERAGE TOTAL PLATE COUNTS (TPCs)
OF GROUND BEEF PATTIES PRODUCED
IN THE COMMISSARY¹

DATE PRODUCED	TPC (COLONIES/GRAM)
May 1, 1980	7.0×10^5
May 2, 1980	9.7×10^5
May 6, 1980	3.7×10^5
May 8, 1980	9.4×10^4
May 9, 1980	3.1×10^4
May 13, 1980	5.1×10^4
May 15, 1980	8.5×10^5
May 17, 1980	4.7×10^5
May 21, 1980	2.7×10^6
May 23, 1980	8.1×10^5
May 27, 1980	1.9×10^6
May 29, 1980	3.4×10^4
May 30, 1980	9.4×10^5
June 3, 1980	9.0×10^5
June 4, 1980	2.0×10^5
June 5, 1980	3.4×10^3
June 6, 1980	1.8×10^4
June 10, 1980	8.0×10^5
June 12, 1980	2.2×10^7
June 13, 1980	7.0×10^5
June 17, 1980	1.2×10^6
June 20, 1980	2.0×10^6
June 24, 1980	9.4×10^5
June 26, 1980	1.0×10^5
June 27, 1980	1.0×10^5

¹TPC values based on an average of all samples analyzed on each date.

TABLE 4.811 (CONT'D.)

DATE PRODUCED	TPC (COLONIES/GRAM)
July 1, 1980	2.2×10^6
July 2, 1980	7.5×10^4
July 3, 1980	2.2×10^6
July 8, 1980	4.7×10^5
July 10, 1980	3.0×10^5
July 11, 1980	2.0×10^6

TABLE 4.812 AVERAGES AND STANDARD DEVIATIONS OF
TOTAL PLATE COUNTS (TPCs) OF FRESH
AND FROZEN BONELESS BEEF AND
FINISHED GROUND BEEF PATTIES

ITEM	FRESH BEEF	FROZEN BEEF	GROUND BEEF PATTIES
n	10	33	31
Log average	3.42	4.12	5.61
Log standard deviation	0.77	0.98	0.78
Mean average ¹	2.6×10^3	1.3×10^4	4.0×10^5
Observed range ¹	6.0×10^2 to 5.1×10^4	3.0×10^2 to 1.4×10^6	3.4×10^3 to 2.2×10^7
Natural limits ¹ (6-sigma)	1.3×10^1 to 5.4×10^5	1.5×10^1 to 1.1×10^7	1.9×10^3 to 8.9×10^7

¹Colonies/gram.

these sampling plans were recommended to put sampling on a sound statistical basis. The sampling plans recommended for frozen and chilled boneless beef were developed by the ICMSF and include limits for Salmonella as well as TPCs. The sampling plan recommended for nonfrozen ground beef was developed by Pivnick et al. (1976) as a proposed Canadian standard. These sampling plans are summarized in Table 4.820.

Both the number of sample units from a given lot (n) and the maximum allowable number of sample units that may exceed the microbiological criterion (c) are specified. The two-class sampling plans are defined by the attributes "acceptable" and "unacceptable"; the three-class sampling plans are defined by the attributes "acceptable," "marginally acceptable," and "unacceptable."

The M values for TPC represent an expression based on experience that meats with TPC values greater than 10^7 have been exposed to conditions favorable to spoilage. The values of M are based on current commercially attainable limits. These values reflect experience that the tested meats with plate counts at a value lower than M usually have not received abusive levels of contamination nor unduly faulty handling. A normal shelf-life would be anticipated.

The case number refers to the stringency of the sampling plan based on the hazard to the consumer from pathogenic or spoilage microorganisms. The most lenient

TABLE 4.820 SAMPLING PLANS AND RECOMMENDED MICROBIOLOGICAL
LIMITS FOR CHILLED AND FROZEN RAW BEEF AND
GROUND BEEF PATTIES

PRODUCT	TEST	CASE	PLAN CLASS	n	c ¹	LIMIT PER GRAM	
						m	M
Carcass meat: chilled ²	TPC	1	3	5	3	10 ⁶	10 ⁷
	<u>Salmonella</u>	10	2	5	0	0	-
Boneless beef: frozen ²	TPC	1	3	5	3	·5x10 ⁵	10 ⁷
	<u>Salmonella</u>	10	2	5	1(0)	0	-
Nonfrozen ground beef ³	TPC	1	3	5	3	10 ⁷	5x10 ⁷
	<u>Salmonella</u>	10	3	5	0	0	0

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¹Figures in parentheses in this column represent the desirable aim. Figures not in parentheses are an interim recommendation.

²Recommended by ICMSF (1974).

³Proposed Canadian Standard (Pivnick et al., 1976).

plan is case 1, that of no direct health hazard. However, case 1 foods are sampled based on utility tests (e.g., general contamination, reduced shelf-life, and spoilage).

These utilities are not related to health hazards, but to aesthetics and economics. Case 1 food is expected to be handled and consumed, after sampling, in such a way so as to reduce the degree of hazard. A case 10 classification indicates a health hazard that is moderate, direct, and with a potentially extensive spread. Case 10 food is expected to be handled and consumed in a manner that reduces the degree of hazard. For example, it is logical to expect that the ground beef patties will be cooked before consumption and this cooking will destroy all or most salmonellae present.

4.83 Salmonella Testing

The commissary lab staff only analyzed the ground beef patties for TPCs due to limited time and staff resources available. On four ground beef patty production dates, five samples of one pound each were delivered to a state Department of Agriculture laboratory for salmonellae testing, none were detected. In addition, the odor, color, and texture of all five samples were evaluated by the state laboratory and classified as normal.

4.84 Time-Temperature Relationship

Time-temperature combinations are critical at many processing points because prolonged exposure to the temperature danger zone can lead to microbiological proliferation.

Proper review of the time-temperature history of a food product can red-flag the process stages at which microbiological proliferation is likely to occur. The time-temperature history was recorded on three separate dates for each of the following critical control points in the commissary: store frozen, store refrigerated, pre-microwave, post-microwave, flake/slice, hopper/grinder number one, hopper/grinder number two, Formax hopper, patty, refrigerated patties--just produced, and refrigerated patties--one-day old. These results are presented in Table 4.840 and Figure 4.840. The maximum holding times given were estimated by commissary and restaurant personnel who are in a position to know.

Once the ground beef patties are produced in the commissary, they are transported to the restaurants in company-owned trucks. The ambient temperature in the truck was recorded during transport. These data are presented in Table 4.841 and Figure 4.841. On September 24 and October 22, the trip from the commissary to the restaurant took 12 hours. On October 7, the same distance took two hours less to travel. The delivery schedule is set up so that the truck driver makes several stops to unload merchandise at other restaurants prior to arriving at the particular restaurant under study.

Four critical control points were chosen at which to record the time-temperature relationship in the restaurant: store refrigerated walk-in, store refrigerated drawer, cook,

TIME 4.840 TIME-TEMPERATURE HISTORY OF FROZEN AND FRESH
BEEF AND GROUND BEEF PATTIES IN THE COMMISSARY

CRITICAL CONTROL POINT	AVERAGE TEMPERATURE, 1 °F				OVERALL AVERAGE	STANDARD DEVIATION	MAXIMUM TIME
	9/4/80	9/29/80	10/6/80				
1. Store frozen	-6.9	-7.0	-6.5	-6.8	0.27	2 mos.	
2. Store refrigerated	30.1	37.3	36.2	34.5	3.88	4 days	
3. Pre-microwave	25.3	25.0	23.1	24.5	1.19	4 hrs.	
4. Post-microwave	26.4	27.7	25.9	26.7	0.93	1 hr.	
5. Flake/slice	29.7	29.1	28.7	29.2	0.50	1 min.	
6. Hopper/grinder #1	29.4	29.1	29.3	29.3	0.15	30 mins.	
7. Hopper/grinder #2	30.1	29.1	29.6	29.6	0.50	30 mins.	
8. Formax hopper	29.7	29.6	29.6	29.6	0.06	30 mins.	
9. Patty	30.2	30.8	30.0	30.3	0.42	45 mins.	
10. Refrigerated patties, just produced	35.7	35.8	33.0	34.8	1.59	2 days	
11. Refrigerated patties, one day old	30.5	31.2	30.2	30.6	0.51	2 days	

¹Refer to section 3.63.

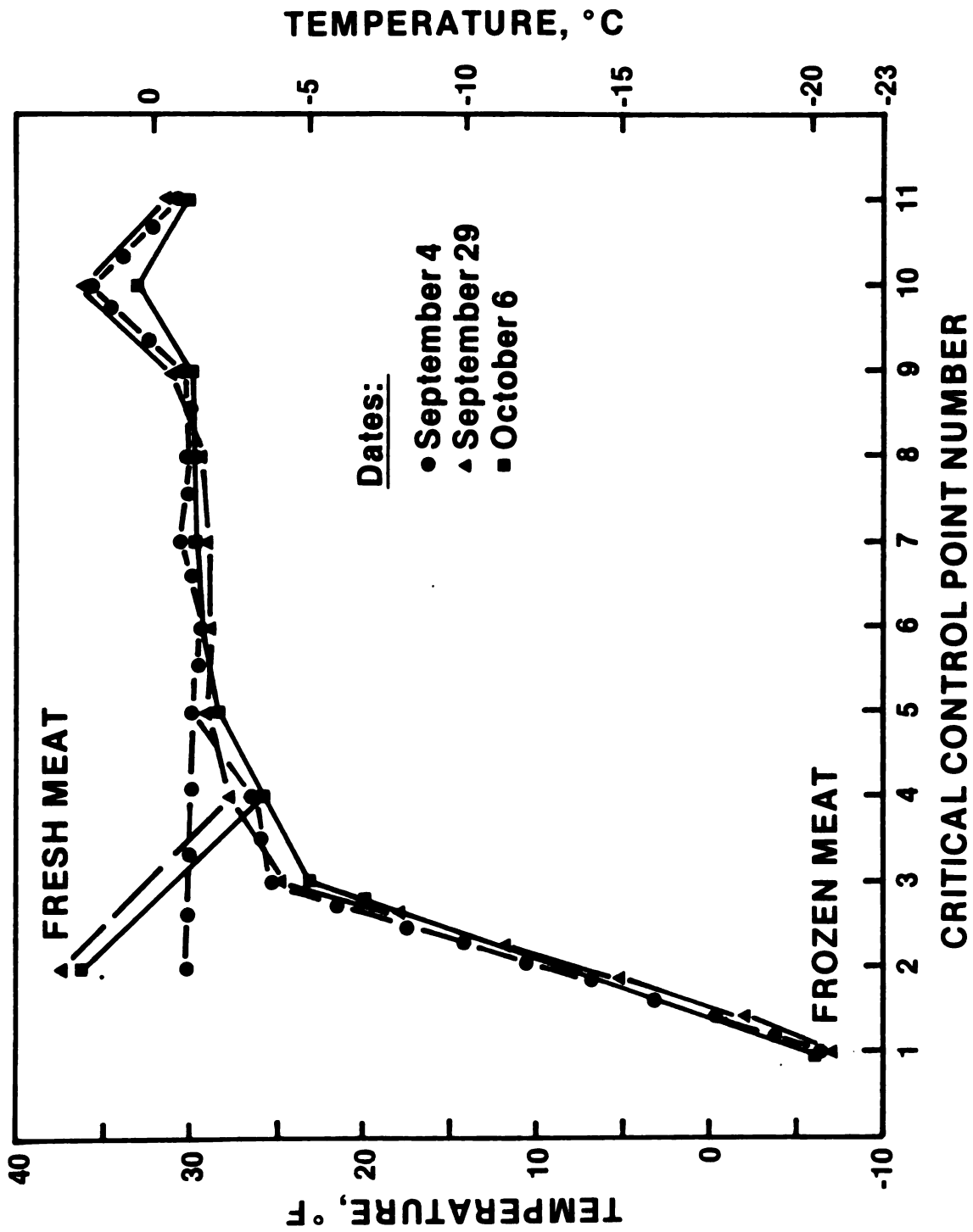


FIGURE 4.840 TIME-TEMPERATURE HISTORY OF FROZEN AND FRESH BEEF AND GROUND BEEF IN THE COMMISSARY

TABLE 4.841 TIME-TEMPERATURE ENVIRONMENTAL HISTORY OF
GROUND BEEF PATTIES DURING TRANSPORTATION
FROM THE COMMISSARY TO THE RESTAURANT

CRITICAL CONTROL POINT	TEMPERATURE, °F				STANDARD DEVIATION
	9/24/80	10/7/80	10/22/80	$\bar{x}$	
12. Assemble/load	39.2	41.0	39.2	39.8	1.04
13. Transport					
0 hours	50.0	42.8	50.0	47.6	4.16
2 hours	50.0	44.6	46.4	47.0	2.75
4 hours	50.0	44.6	41.0	45.2	4.53
6 hours	50.0	46.4	41.0	45.8	4.53
8 hours	50.0	50.0	39.2	46.4	6.24
10 hours	48.2	46.4	39.2	44.6	4.76
12 hours	46.4	-	39.2	42.8	5.09
14. Arrive at the restaurant	44.6	46.4	37.4	42.8	4.76
15. Restaurant walk- in storage					
0 hours	44.6	46.4	35.6	42.2	5.79
2 hours	42.8	46.4	33.8	41.0	6.49

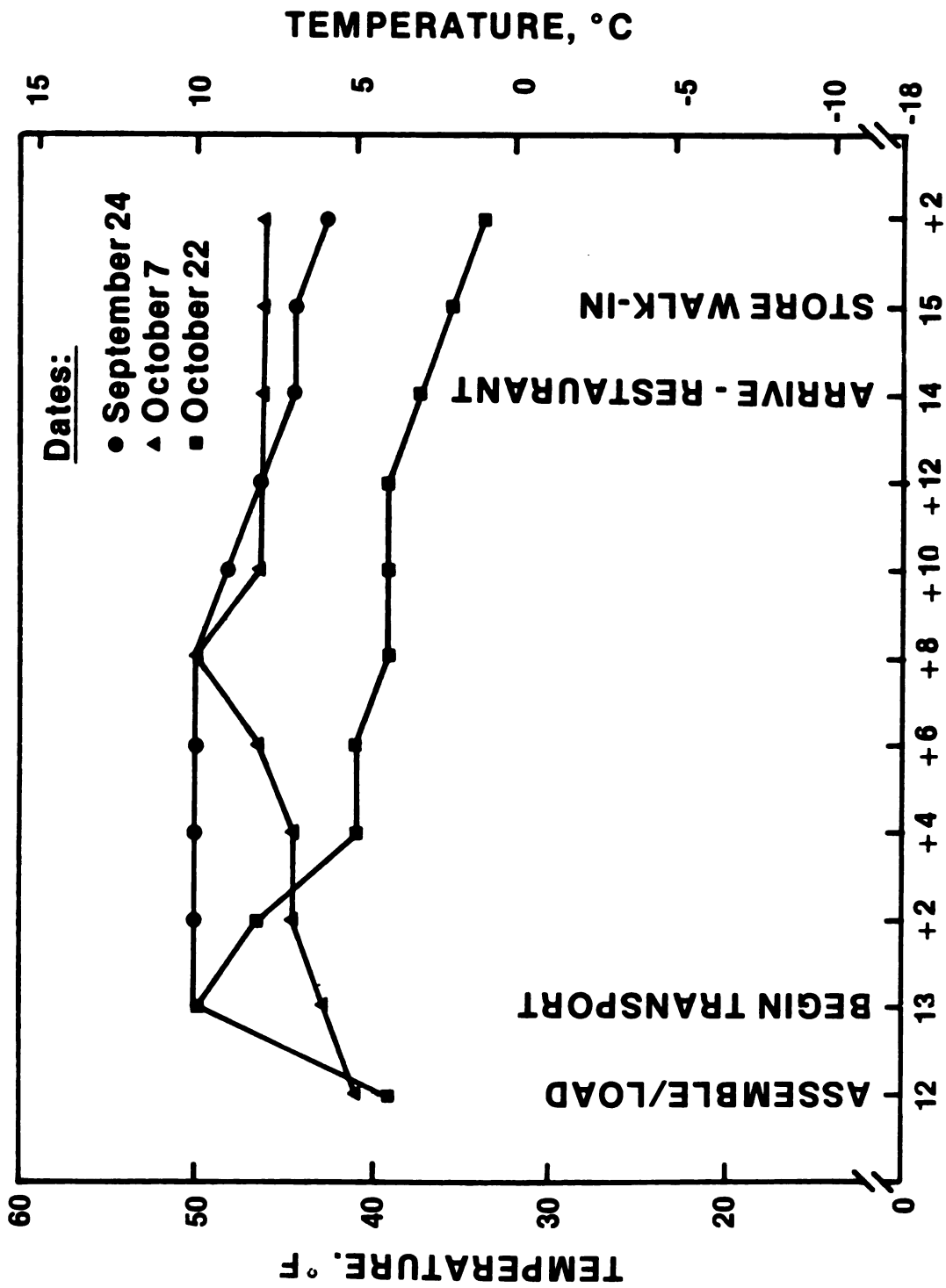


FIGURE 4.841 TIME-TEMPERATURE HISTORY OF GROUND BEEF PATTIES DURING TRANSPORT AND STORE WALK-IN

and serve. These data are presented in Table 4.842 and Figure 4.842. Figure 4.843 summarizes the average temperature history of the ground beef patties produced in this commissary foodservice system. The numerical values for critical control point numbers 13 and 15 were obtained by averaging the recorded values for these points.

The temperature danger zone, 45° to 140°F (7° to 60°C), and the identified growth range for Salmonella have been superimposed on Figure 4.843. Jay (1978) observed that the lowest temperatures at which growth has been reported are 41.5°F (5°C) for Salmonella heidelberg and 43.2°F (6°C) for Salmonella typhimurium. Temperatures of about 113°F (45°C) have been reported by several authors to be the upper limit for growth.

In regard to the temperature danger zone, the average temperatures of two critical control points (transport and serve) fall within the zone. Transport times and temperatures are of paramount importance because of the amount of time that the product is likely to spend in the danger zone. The critical control point serve is less important because a relatively short amount of time is involved and many of the heat-labile pathogens will be destroyed during the cooking operation.

4.9 Analysis of Nutrition Results

The nutritional profile of the ground beef patties was estimated using values from the U.S. Department of Agriculture Handbook No. 456. These values were compared

TABLE 4.842 TIME-TEMPERATURE HISTORY OF GROUND BEEF
PATTIES IN THE RESTAURANT

CRITICAL CONTROL POINT	TEMPERATURE, °F			STANDARD DEVIATION	MAXIMUM TIME
	9/4/80	9/25/80	9/29/80	$\bar{x}$	
16. Store refrigerated walk-in	33.3	34.2	31.9	33.1	1.16 2 days
17. Store refrigerated drawer	33.6	36.9	34.0	34.8	1.80 1 day
18. Cook	162.1	164.4	157.5	161.3	3.51 3 mins.
19. Serve	120.0	121.9	115.7	119.2	3.18 5 mins.

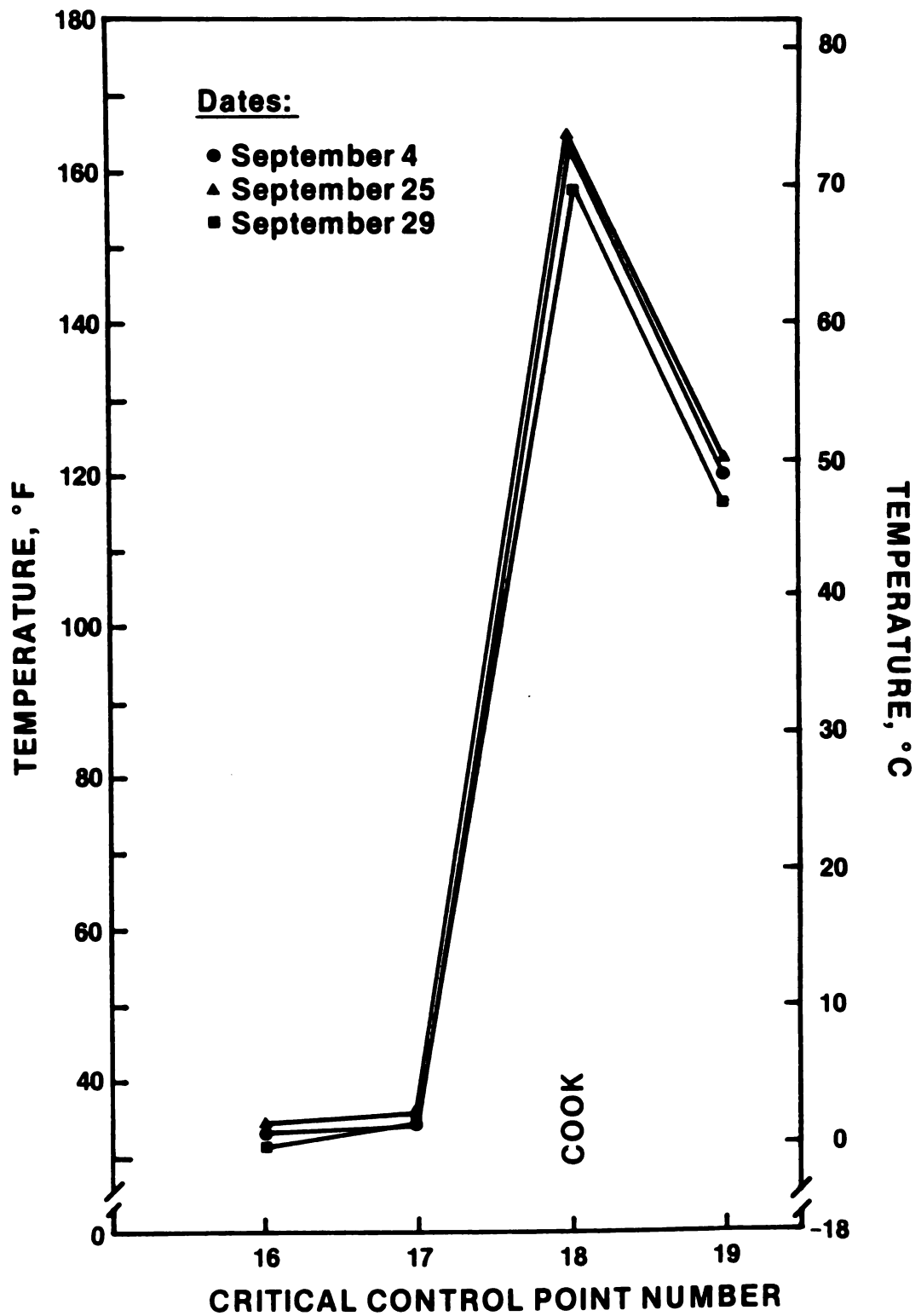


FIGURE 4.842 TIME-TEMPERATURE HISTORY OF GROUND BEEF PATTIES IN THE RESTAURANT

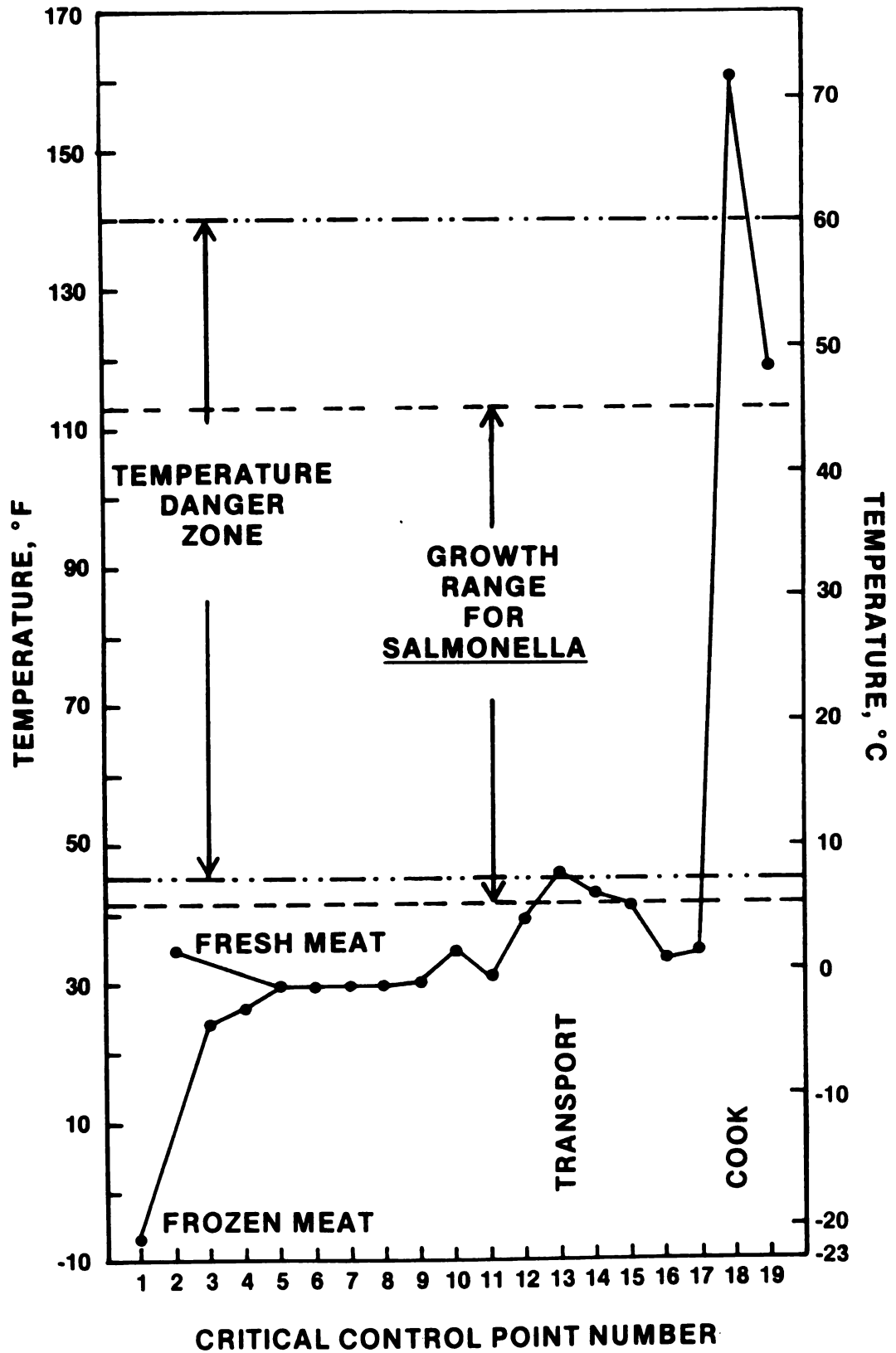


FIGURE 4.843 AVERAGE TEMPERATURE HISTORY OF BEEF AND GROUND BEEF PATTIES IN A COMMISSARY FOODSERVICE SYSTEM

to the 23 to 50 year old age group's Recommended Daily Dietary Allowances (RDA) to determine the Index of Nutritional Quality (INQ). The INQ is an expression of the nutrient density of a food, the ratio of the extent to which a food meets the requirement for a specific nutrient to the extent it meets the needs for energy for an individual.

If a food has an INQ of one or more for four nutrients or an INQ of two or more for two nutrients, that food makes a significant contribution to the individual's nutrient intake and it may be identified as nutritious. Ground beef patties are, therefore, identified as nutritious for both males and females in the 23 to 50 age group based on the INQs presented in Table 3.730.

The ground beef patties are, therefore, considered a source of protein, phosphorus, iron, and riboflavin for both males and females. In addition, the patties are a source of niacin for males. The ground beef patties are good or excellent sources of protein and phosphorus for both males and females, but a good or excellent source of iron only for males. These results are summarized in Table 4.900.

TABLE 4.900 A CLASSIFICATION OF THE NUTRIENT
CONTENT OF GROUND BEEF PATTIES
BASED ON THE INDEX OF NUTRI-
TIONAL QUALITY AND THE RECOM-
MENDED DAILY DIETARY ALLOW-
ANCES FOR THE 23 to 50 AGE GROUP

NUTRIENT	A SOURCE		A GOOD OR EXCELLENT SOURCE	
	MALES	FEMALES	MALES	FEMALES
Protein	X	X	X	X
Phosphorus	X	X	X	X
Iron	X	X	X	
Riboflavin	X	X		
Niacin	X			

CHAPTER 5

DISCUSSION AND RECOMMENDATIONS

Several quality assurance principles were applied to a commissary foodservice system that annually produces in excess of 15,000,000 ground beef patties. The Hazard Analysis Critical Control Point (HACCP) concept was utilized as a template to point out the deficiencies that existed in this system. The Pareto principle and analysis was used to red flag the "vital few" sensitive equipment locations.

The ground beef patties were analyzed to determine whether the percent fat in the pretest had a measurable effect on either the percent fat in the patty or the patty weight. The effect of the pressure setting on the patty forming machine was examined to ascertain whether it influenced patty weight. A process capability study and analysis was performed to determine whether the process for producing ground beef patties was in statistical control.

Microbiological analyses were conducted on both the raw ingredients and the finished products. The nutrient profile of the ground beef patties was examined and methods for evaluating the sensory aspects of the product were evaluated. The data generated provided an objective means for evaluating the effectiveness of the QA/QC system.

5.1 Quality Control/Quality Assurance

The word quality can be defined in many ways; however, the definition should be in line with what the firm's target market perceives it to be. One generalized definition of quality is fitness for use, plus reliability, delivered at a marketable price. Quality control (QC) has been defined as those operational techniques and activities that sustain a quality of a product or service that will satisfy given needs. Quality assurance (QA) has been described as all those planned or systematic actions necessary to provide adequate confidence that a product or service will satisfy given needs.

5.11 Scope of Quality Assurance/Quality Control

Many, if not most, of the definitions and uses of the word quality explicitly or implicitly embrace the notion of better or good. This usage is what Juran and Gryna (1970) characterizes as marketplace quality. In a competitive economy, consumers have a choice as to what products they will buy based on a myriad of factors such as style, quantity, availability, size, perceived value, price, and quality. Marketing or related groups are responsible for determining the marketplace quality, based on information concerning the needs and wants of the target market. The characteristics of marketplace quality, obtained through marketing intelligence, are described by a set of specifications.

The production department makes the product on the basis of the specifications provided to them. The task of

quality assurance/quality control is to provide information on the likelihood, on a given day, that the product quality is within specifications. Stated formally, QA/QC personnel make statements such as, "There is no persuasive evidence that the product is not other than specified (accepting the null hypothesis)," or "It is quite likely that the product is not within specifications." In cases where product quality does not conform to specifications, it is production's responsibility to take action based on established management guidelines.

It is sometimes difficult to identify the special characteristics in companies that excel in quality versus those that have fallen behind. Certainly, the pacesetters are managed by people who insist on satisfying the target market needs, and will settle for nothing less. Good lines of communication between upper management and the QA/QC department are essential in meeting the long-term objectives of the organization. The QA/QC department needs to be a part of the total corporate team that provides the target market with quality, value, and service.

Employees who are "quality minded" possess an attitude about quality that does not allow them to feel right about a product that is below company standards. Unless supervisors make employees believe that only a top quality product will be tolerated, the battle for quality will be a difficult one. This type of attitude stems from a pride in knowing that you are doing the best job possible under

the circumstances.

5.12 Costs of Quality

Several of the larger companies have an organized approach to QA/QC and product safety. Those firms classified as "shakers and movers" have recognized the importance of a quality emphasis, unlike other firms who have failed or been unwilling to comprehend the significance of QA/QC. The nemesis of QA/QC, sanitation, and food product safety is the dollar in the fact that, in normal accounting practices, QA/QC do not show a profit. Those who control the financial resources of an organization are often individuals whose knowledge regarding QA/QC is extremely limited. To sell the importance of quality to these individuals, it is often necessary to relate quality in terms of dollars.

The costs of quality have been defined by the American Society for Quality Control in the following four categories: prevention, appraisal, internal failures and external failures. Prevention includes those costs associated with personnel engaged in designing, implementing, maintaining, and auditing the quality system. Appraisal costs are the costs resulting from measuring, evaluating or auditing products, ingredients, and purchased materials to assure conformance with established quality standards. Internal failures involve costs associated with defective products, ingredients, and materials that fail to meet quality requirements and result in manufacturing losses. External failures are quality costs arising due to

defective products being shipped to customers.

The objective of monitoring quality costs in each of these four categories focuses on the improvement of organizational effectiveness. The first step is to identify all of the activities conducted to achieve fitness for use of the end product. Next, the avoidable and unavoidable costs of all of these activities are determined. This information is then interpreted and made available to all concerned. The next step entails the identification of opportunities for optimizing the firm's quality costs. Finally, a running tally of trends in each of these four categories of quality costs is maintained. These trends usually permit management to realize the categories in which the costs are concentrated. In addition, management becomes aware of how small the prevention costs are in relation to the total quality costs.

5.13 Responsibilities Related to QA/QC

The QA/QC function must exist at three levels of the foodservice system under study: top management, the commissary, and the restaurants. Top management is charged with the responsibility for developing corporate procedures and policies regarding QA/QC. These statements of the organization's corporate strategic quality plan should be an integral part of the firm's overall mission. This quality system must be clearly described in writing and approved by senior management. Comprehensive sanitation and product standard methods and procedures must also be developed.

In addition, top management is accountable for finished product standard quality and regulatory compliance. Senior management representatives are also responsible for the development of training materials for use at both the commissary and restaurant levels. The onus is on top management to prepare a complete program for monitoring the quality of products in the commissary and the retail outlets.

Commissary QA/QC operates at a different level to fulfill the corporate strategic quality plan. Sufficient authority and organizational autonomy must be provided so that the QA/QC personnel can function without unnecessary administrative pressure. If QA/QC staff members report directly to the commissary plant manager and depend on that individual for personnel evaluations, the possibility exists for a superficial emphasis on quality. Separation of lines of authority and responsibility is necessary if the QA/QC effort is to be effective.

The commissary QA/QC representatives are in charge of setting up personnel training programs. They are responsible for monitoring product quality from purchasing through transportation to the restaurant. The QA/QC commissary staff is responsible for checking products for conformance with specifications, determining the nature and extent of the variations, and establishing the significance of these variations. The QA/QC personnel are also in charge of monitoring laboratory and production data. In addition,

the production departments must be provided with reliable technical expertise by the QA/QC staff and a means for outside technical help in special circumstances. The commissary QA/QC inspectors have the responsibility for providing accept-reject decisions relative to both incoming materials and products produced in the commissary.

The key to a successful and effective system for monitoring quality in a commissary foodservice organization lies in the emphasis on quality in the individual restaurants. If the system is going to deteriorate at any organizational level, it is most likely to happen at the retail outlet level. The likelihood of a system breakdown is enhanced due to the multitude of locations and personnel. Every individual on the payroll of the restaurant must be made aware of their role in the corporate strategic quality plan by making an orientation related to quality concepts, procedures, and policies a part of every individual's training program. Quality problems should be reported to the store's manager or the appointed representative so that the situation can be remedied as soon as possible.

Service staff should be encouraged to report customer complaints to management, and they should then be carefully analyzed. Product quality must be monitored from receipt to service, and restaurant staff members should be encouraged to be constantly on the alert for deviations from the organization's quality specifications. Restaurant management must maintain a communication link

with commissary QA/QC personnel. The goal is to minimize quality problems and, ultimately, increase customer satisfaction.

5.14 Inspections

Fundamental to the success of a QA/QC program is the proper support and implementation of an inspection program. The inspection results provide information to management as to whether the system is effective. The underlying philosophy is that the earlier a defect or nonconformity is detected, the more the organization can save. The system of inspections and the authority for inspections should be clearly described in writing and be sanctioned by senior management. The status of inspections and reinspections must be readily determinable. Inspection staff, equipment, and procedures should be available as required to evaluate the process. These inspections are undertaken utilizing the specifications, procedures and policies defined by the organization's top management.

It is necessary for all inspection personnel, in their roles as representatives of the corporate quality system, to meet defined minimum qualification requirements for their positions. They should have readily available the organization's specifications, procedures, and policies regarding quality that have been defined by management. The information should also include test procedures, work instructions, and other documents necessary to effectively perform the inspection role in the strategic quality plan.

The inspection personnel should have access to the necessary inspection equipment (e.g., thermometers, scales, analytical equipment, etc.) to do their jobs efficiently. When appropriate, this equipment should be calibrated prior to use and a record of this calibration should be maintained. Food products and ingredients that fail to meet the acceptance criteria prescribed by top management should be identified. It is imperative that these defective or nonconforming products be segregated from acceptable products to prevent the inadvertent use of this material. Final acceptance of an inspected product must not be authorized prior to the resolution of all defects recorded for the product. The correction or elimination of nonconformities must be verified and recorded.

Inspection results must be reported in a predefined, logical manner so that records of inspections are maintained. Minimally, these inspection records should contain the following information: the inspector's name, the date, identification of the product (such as, invoice or batch number), the type of observation, the inspection procedure, the inspection results, and acceptance and/or the action taken in relation to any identified deficiencies. Organizational standards and regulatory codes may also require recording the inspection equipment used, calibration data, special procedures, and the qualifications of personnel. In the case of identification of continuing conditions adverse to the maintenance of quality,

it is the responsibility of the quality system to notify top management. Top management must then take the necessary action to minimize or eliminate these conditions. If no action is taken, the corporate strategic quality plan is negatively affected.

5.2 Hazard Analysis Critical Control Point Concept

The Hazard Analysis Critical Control Point (HACCP) concept is a preventive approach designed to bring the potential dangers associated with the production of a food product to management's attention. The thrust of HACCP is the development of an objective process associated with estimating the risks of producing and marketing a food product. HACCP is a communication tool designed to minimize the errors that can eventually become costly to the foodservice industry and its customers both in terms of dollars and health. The organization that allows a defective product to harm even one consumer faces a serious erosion of public confidence, potential law suits and the ensuing ramifications, and the loss of sales and profits. HACCP is a preventive system focused on bringing potential dangers to management's attention for timely correction rather than after the health hazard has surfaced in the form of consumer illness. The HACCP procedure centers on an evaluation of four broad areas related to food product production: ingredient control and storage, equipment sanitation, personnel sanitation and time-temperature

combinations.

5.21 Ingredient Control and Storage

The objectives of the purchasing function include maintaining adequate stock levels, minimizing the investment in inventory, maintaining quality, sustaining the firm's competitive position, and maintaining value. The development of ingredient specifications aid the organization in providing qualitative, sensory, quantitative and microbiological control. The use of standard purchase specifications is critical to the success of HACCP.

Standard purchase specifications are precise, written descriptions of the quality and quantity factors desired in each product procured. Minimally, the standard purchase specification should include the name of the item, the quantity needed, the grade desired, the number of items per package, the unit on which the price is based and any other additional factors necessary to obtain the correct product. In the case of beef, additional factors would include the geographical area of production, the maximum microbiological load permitted, the state (i.e., fresh or frozen) in which the product should be delivered, the maximum product temperature at delivery, the specified maximum fat content, and relevant sensory factors particularly the factors that most strongly govern the firm's quality of design. These specifications may be altered based on raw material supply, menu item changes, and price. There should be some rational reason for the alteration, known to all, and known in

advance of need.

Formal buying methods involve providing each supplier with a set of written specifications and the quantity needed for that buying period. The competitive buying procedures facilitate communication between the buyer and the supplier and minimize problems with delivery of unacceptable merchandise. Ultimately, purchasing decisions must be based on the intended use of the product coupled with a value analysis.

The standard purchase specifications should be used by the receiving department to evaluate the quantity and quality of materials delivered. The objectives of food receiving are to perform an inspection, determine the quantity, evaluate the quality, check prices, and make an accept/reject decision. No merchandise should be allowed to be used until it has been sampled, examined or analyzed and accepted as satisfactory. In addition to a physical inspection, samples of beef must be evaluated for microbiological load, product temperature, fat content, grade, and sensory factors (i.e., odor, feel, appearance). The delivery truck should also be inspected to determine freedom from contamination and infestation.

The successful food receiving operation depends upon competent, well-trained personnel who are capable of evaluating product quality. The weights of incoming products must be determined with an accurate scale. Even if the supplier is trustworthy, unintentional errors can still

occur. All items delivered should be recorded on the receiving department's daily report that lists the date of delivery, the invoice or purchase order number, the supplier, a description of the merchandise, the quantity delivered, the unit and unit price, and the price extension. In addition, the report should list whether the product was accepted or rejected, and if rejected, the reasons why.

All meat items should be tagged upon receipt to facilitate product traceability. The tag should contain the following information: date of receipt, supplier's name, description of the product, the weight, the unit price and the price extension. This system of tagging food products helps, first, guarantee proper stock rotation and the use of the first-in, first-out (FIFO) inventory system and, second, product traceability.

The meat products should be stored as promptly as possible after delivery. The objectives of food storage include maintenance of adequate stock levels, minimizing the losses due to theft and pilferage, and minimizing product quality losses due to contamination, spoilage and microbiological proliferation. The individual in charge of the storage areas is accountable to management for systematic inventory control. The scope of inventory control is influenced by the particular storage area under consideration. Regardless of the storage conditions, the food products should be monitored and inspected at

regularly scheduled intervals while in storage.

The inspections should include both physical and chemical tests defined in the organization's policies and procedures manual. Tests must include product temperature, pH, color, odor, and appearance, and microbiological loads. The refrigerated storage areas should be checked daily for cleanliness, freedom from contamination, and ambient temperatures. The recommended storage temperature for refrigerated meat is 40°F (4°C) or below. Frozen storage areas should be maintained at temperatures of 0°F (-18°C) or below. Stock rotation and the FIFO inventory system are essential if product deterioration is to be minimized.

Product theft and pilferage can be reduced if a perpetual inventory system is established for meat items. Stock record cards record at all times the amount of a product on hand. This perpetual inventory system can be maintained on the firm's computer. Additions to and deletions from the perpetual inventory are made when products are received or issued to production, respectively. Perpetual inventories offer the additional advantage of tracking product usage and, therefore, can be used to calculate raw material yield. An actual count of what is in storage is called a physical inventory. The physical inventory, usually taken at least once a month, verifies the perpetual inventory figures and expedites the product purchasing process. Storage areas should be locked when not in use to minimize theft and pilferage.

In-process product control is important if corporate specifications are to be realized. The QA/QC staff and the production supervisor and personnel monitor the product before and during the manufacturing process. Product evaluation should take place at the identified critical control points during the process flow. Samples for analysis are sent to the QA/QC lab and results returned to the processing supervisor in time to permit process modifications based on the lab analysis. Since timing is crucial, these in-process tests should be classified as high priority.

Finished products should be evaluated on an on-going basis to determine whether they conform to the established specifications. The ground beef patties must be tested for fat content, odor, color, appearance, and microbiological load. Finished patties should be coded with the date of production and the count and/or weight per case. This system of coding will permit product traceability and expedite a recall program, if one is deemed necessary. In addition, the FIFO inventory system will be easier to maintain.

5.22 Equipment Sanitation

Equipment sanitation is a critical control point because inadequate cleaning and sanitizing of equipment and cross-contamination of food products can be responsible for significant health hazards. An effective equipment sanitation program is the result of extensive planning, personnel training, close supervision of cleaning and sanitizing activities, and attention to the details of the established

cleaning procedures. Equipment sanitation should be a part of the firm's planned approach to an effective cleaning program.

Written cleaning and sanitizing procedures provide a common reference point and expedite the overall effort. Unacceptable equipment cleaning can be corrected if management is willing to develop cleaning schedules and specific procedures for each piece of equipment and production area in the commissary and restaurant. These procedures should be communicated to workers in a well-planned orientation and training program, and posted in water-proof coverings adjacent to each piece of equipment and area.

Detailed checklists should be developed for supervisory use in evaluating the cleaning and sanitizing effort. Employee involvement is the key to keeping the program heading in a positive direction. If informed of the reasons behind targets and procedures on a regular basis, cleaning personnel will tend to put suggestions into practice more easily, recommend improvements more frequently, and keep the program working. Cleaning and sanitizing personnel should be cognizant of how they are doing relative to the total effort.

Food production equipment is maintained in a clean and sanitary condition by the application of cleaning systems after each production run. Cleaning systems consist of a sequence of rinse, detergent, and sanitizer applications in combination with the proper concentrations and

temperatures. An effective cleaning system not only controls the accumulations of soil, but also the development of microorganisms on equipment surfaces. The objective is to prevent the contamination of the food product when it comes into contact with the equipment. The cleaning and sanitizing effort should be economically performed without such adverse side effects as contamination of the food product by cleaner and sanitizer residues or corrosion of the equipment.

Today, foodservice operations must institute a program of cost-conscious sanitation to realize effective cleaning and sanitizing with regard to the investment in these areas. A cost-benefit analysis is to a tool to evaluate all relevant factors, such as labor cost, chemical cost, water usage, cleaning times and energy consumption related to heating water and producing steam. The cost-benefit analysis attempts to quantify these costs and compare them to the benefits realized.

5.23 Personnel Sanitation

Personnel sanitation is a critical control point because humans are often associated with the contamination or mishandling of food products. One of the most important responsibilities of foodservice management is to train employees in the principles and procedures of foodservice sanitation. Employees should be trained to approach the basic operating activities of a foodservice with a sanitary outlook. The training of foodservice workers regarding

sanitary food storage, production, and service will not only minimize problems with foodborne disease outbreaks, but will also maximize customer satisfaction. A formal training program also offers other advantages related to a reduction in employee turnover, increased product and service consistency, higher productivity, decreased absenteeism, higher morale, and an increased probability that the job will be accomplished in an approved manner.

A planned training effort should be executed in an atmosphere that enhances employee learning. To be effective, employee training should be a continuous or on-going program. The National Institute for the Foodservice Industry (NIFI) has developed a program for certification of foodservice management and employees in the area of applied foodservice sanitation. NIFI's major mission is the education and training of people to meet the foodservice industry's expanding needs. The NIFI certification program should be a vital part of any foodservice operation's total training effort.

Personnel training programs should cover the specifics of acceptable foodhandling techniques, personal hygiene, proper cooking and serving methods, and general sanitation of the physical facility. The core of a personnel sanitation program can stem from the Ten Commandments of Safe Foodservice (NIFI, 1978). These Ten Commandments are a positive approach to the most frequently cited sanitation violations in foodservice operations. Specifically, the

Ten Commandments of Safe Foodservice are as follows:

1. Maintain an internal product temperature of 45°F (7°C) or less when refrigerating potentially hazardous food products.
2. Use extreme care in storing and handling food products prepared in advance of service.
3. Cook or heat-process food products so that they reach the recommended temperatures.
4. Require strict personal hygiene on the part of all foodservice workers and prevent infected employees from entering food storage, production, and service areas.
5. Monitor internal product temperatures of food in hot-holding devices to be certain that the temperature is 140°F (60°C) or greater.
6. Carefully inspect and clean raw ingredients that are added to food products requiring minimal or no cooking.
7. Rapidly reheat leftovers to a minimum internal product temperature of 165°F (74°C).
8. Avoid cross-contamination from raw to cooked and ready-to-serve food products by hands, utensils, and equipment.
9. Clean and sanitize all food-contact surfaces after every use.
10. Specify that food products be obtained only from approved sources.

These Ten Commandments of Safe Foodservice should be communicated to all new employees to provide the basis for a sanitary outlook. They should also be periodically reviewed with employees who have worked for the organization for some time to serve as a reminder. Both commissary and restaurant management and employees can minimize problems with personnel sanitation by emphasizing adherence to these Ten Commandments of Safe Foodservice.

5.24 Time-Temperature Relationship

Time-temperature is a critical control point because several outbreaks of foodborne disease have been linked to unacceptable food product storage, heating, and cooling practices. Within each foodservice system, identification of time-temperature critical control points involved in food handling is of paramount importance for adequate control of food safety and quality. In addition, sensory attributes of the food product can be negatively affected through inadequate time-temperature control. To minimize these adverse effects on the food product, it is recommended that the item not be exposed to the temperature danger zone any longer than absolutely necessary.

The temperature danger zone covers the range of 45°F (7°C) to 140°F (60°C), as defined by the U.S. Public Health Service. The average temperature history of the ground beef patties revealed that the product is likely to be in the temperature danger zone during two of the critical control points: transport and serve. The transportation of

the patties took as long as 12 hours from the time the product left the commissary until it arrived at the restaurant. Product environmental temperatures ranged from 39.2°F (4°C) to a high of 50°F (10°C). These temperatures should be monitored on a regular, random basis as a part of the overall quality system. Any problems associated with delivery truck refrigeration equipment can be quickly identified and corrected.

Product temperatures were also in the temperature danger zone during the serve critical control point. This problem is not major, however, because the time involved is no more than five minutes. In addition, many of the heat-labile non-spore forming pathogens will be destroyed during the cooking operation.

Raw fresh and frozen beef delivered to the commissary should be examined to obtain an average product temperature. Accept/reject decisions should be based, in part, on that temperature check. Products arriving at the commissary with temperatures in excess of 40°F (4°C) should be classified as marginal and should be accepted or rejected based on the results of additional inspections regarding microbiological load. Likewise, ground beef patties delivered to the restaurant should arrive at temperatures of 40°F (4°C) or below. It is important to have a member of the management team or its representative present to check and record these incoming product temperatures.

Products stored refrigerated or frozen in the commissary and chilled in the restaurant should be checked daily to determine internal product temperature. In addition, storage area temperatures should be monitored daily to minimize potential problems associated with microbiological proliferation and food spoilage. Establishing and monitoring time-temperature standards in both the commissary and restaurants provides a practical method for estimating product quality and safety. Once these standards are established by management, they must be communicated to lower levels of management and the employees during the training phase. The individuals involved should be trained in methods of accurately and correctly determining and recording product and storage area temperatures.

5.25 HACCP as a Management Tool

The HACCP procedure was used as a template to analyze this commissary foodservice system. HACCP was designed to identify system deficiencies so that corrective action can be instituted before actual problems surface. HACCP can minimize errors expensive to both the organization and its target market by providing information to be used as the basis for management action. The value of HACCP is precisely what management makes of it. System deficiencies can be ignored at the risk of increased health hazards, decreased sales and the potential ultimate destruction of the organization. Alternatively, the identification of these deficiencies can lead to their correction.

HACCP feedback characteristics provide a measure of management efficiency and effectiveness. If management is sincerely interested in satisfying the needs and wants of the target market at a profit, the information obtained as a result of the HACCP investigation can provide the basis for system alteration and fine-tuning. The HACCP concept has a direct impact on the firm's bottom line because increased satisfaction of the organization's clientele will enhance the firm's profitability.

5.3 Ground Beef Patty Weights

Ground beef patty weights were recorded and analyzed using both covariant analysis and least-squares linear regression. The covariable was the pressure setting on the Formax patty machine in psi. This covariable was investigated to determine its effect, if any, on the weight of the ground beef patties. The regression analysis investigated the effect of the percent fat in the raw beef (pretest) versus the percent fat in the ground beef patty (post test) and the patty weight. In addition, the process capability procedure and analysis was used to determine whether the process for producing the ground beef patties was in statistical control.

5.31 Covariant Analysis

The GENSTAT V computer program used to analyze the effect of the covariable psi adjusted the data to an average psi to facilitate the analysis. The covariate analysis for batches indicated that no significant differences

($\alpha = .05$) existed for batches. Any differences that did appear can be explained by any factor correlated or confounded with batch (e.g., different production days, different product temperatures, or different percentages of fat).

Most of the defined differences were associated with position. The position differences were significant ($\alpha = .05$) due to either unequal pressure exerted by the Formax patty machine in the four different positions or a different mechanism for delivering the meat to the four positions, or some other unknown differences. A posterior test on all possible contrasts failed to reveal where the differences existed. No trends could be pinpointed in positions using the Bonferroni t-test.

It appears that, as the proportion of frozen meat in a batch of ground beef increases, the patty weights decrease. This relationship may be due to the fact that, for a given psi, it is not as easy to squeeze the air out of the frozen meat as it is from the fresh meat. It is not possible to accurately control the patty weights by altering machine pressure. Pressure was not specifically identified as a factor that influences the weight of the ground beef patties. Patty weights are controlled within a relatively tight range for each batch as evidenced by the standard deviation. Whatever problems there may be with weight control, they cannot be attributed to the patty machine. This analysis did not identify the specific factors that

have an effect on patty weights. Patty weight control is discussed further under Process Capability Analysis.

5.32 Percent Fat Analysis

The least-squares linear regression analysis examined the effect of the percent fat in the raw beef (pretest) on the percent fat in the ground beef patties (post test). Even though a possible correlation was identified between these variables, the coefficient of determination indicated that only 42 percent of the variance in the post test could be attributed to the linear relationship with the pretest. Either there were confounding variables, or the relationship between the post test and the pretest was confounded by other factors. Therefore, it will be difficult to accurately predict the post test from the pretest as the regression line is almost horizontal. In conclusion, approximately 60 percent of the influence on the percent fat in the ground beef patties was attributable to factors other than the percent fat in the raw beef.

The percent fat in the pretest was also analyzed to determine if this value had an effect on patty weight. A negative correlation of -0.02 existed between the percent fat in the pretest and patty weight. This negative correlation appears to indicate that, as the fat content increased, there was a slight decrease in patty weight. This relationship is not very strong and it appears that there is no strong causal relationship between pretest fat contents and patty weights.

Based on the identified desires of the target market, management must decide whether there is an appreciable quality difference related only to the fat content of the ground beef patties and whether the fat content of the patties should be carefully controlled. The problems associated with not controlling the amount of fat include: yield problems, legal problems, economic problems, and possible flavor effects. The meat room production staff is not making a complete adjustment for the actual fat content of the boneless beef and beef plates. The single fat sample in the pretest may not accurately represent the actual fat content of these raw materials.

If the pretest is to be a quality measure, there should be a nearly 100 percent correlation between the pretest fat content and the post test fat content. Sixty percent of the variability is unaccounted for. If the firm wants to use the pretest results as a guide to the formulation of ground beef, they should try to identify the source of the remaining variability.

5.33 Process Capability Analysis

The process capability study and analysis was conducted to 1) determine the precision with which patty weights can be controlled, 2) discover the presence of uncontrolled variation in the patty weights, and 3) to make recommendations to correct those problems, if they can be corrected. The observed grand mean, $\bar{\bar{X}}$, of the patty weights was 44.32 grams compared to the corporate

specification of 45.4 grams ± 1 gram. The frequency (percentage) histogram and the cumulative percentage (normal probability) plot were constructed and analyzed.

The analyses showed that the process is not in statistical control, and, moreover, is producing product 50 percent of which is out of specifications. This figure covers the range of 44.4 to 46.4 grams established by management. Over one-half of the patty weights obtained in the process capability procedure failed to fall within the acceptable range.

It is therefore concluded that the process is not capable of meeting the specified tolerances except as noted in the next section. Management must decide what to do based on the following alternative courses of action. First of all, the tolerances can be widened to reflect what is realistically obtainable. Based on the analysis, a specified tolerance of 44 grams ± 2 grams may be more realistic. This widening of the tolerance would bring substantially all of the patties within the specified range without any alteration in the average patty weight.

Management might also consider changing the process to realize the original specified tolerances. This change could involve a large investment in capital to purchase a patty machine capable of meeting the specified tolerances. Finally, management could decide to stop talking about the standard for patty weights. The standard would be removed from the Meat Department Daily Weight and Fat record form

and the ground beef patties would no longer be weighed. In two or three years, the standard for patty weights will be forgotten. In addition to decreasing the inspection time required, this option would also rid the organization of a standard that it is not capable of maintaining. Ground beef patties would be sold to the restaurants based on count, not weight.

This last alternative course of action may be the most desirable because it is the least costly. Any decision regarding the specified standard for ground beef patty weights must be made by management after completing a cost-benefit analysis of each alternative. Management does have one other possible course of action; that is, do nothing. However, making no decision is, in fact, a decision to remain with the present standard even though it is unattainable. This option is not recommended simply because it does not make good business sense.

As discussed previously, the average weights vary with batch for unknown reasons. Therefore, the use of an $\bar{x}$ chart is not recommended. However, a range chart might prove useful: take and weigh one patty from each position and plot the values of the observed range in weights on the $\bar{R}$ chart (Figure 4.522). This will determine whether the observed range falls within or outside of the range limits. When the range falls outside of the limits, the firm should try to find out what is causing the variation.

5.34 Batch Mixing of Ground Beef Patties

Even though there are specifications, in practice there are at least four independent variables that determine the fat content of the ground beef patties. The four raw product variables are the weight, in pounds, of the boneless beef, b ; the fat fraction of the boneless beef, F_b ; the weight, in pounds, of the beef plates, p ; and the fat fraction of the beef plates, F_p . The batch weight, h , is determined by the weight of the boneless beef, b , plus the weight of the beef plates, p :

$$h = b + p$$

The fat fraction in the ground beef patties, F_h , is expressed by the following formula:

$$F_h = \frac{(F_b \times b) + (F_p \times p)}{(b + p)}$$

Assuming a total batch weight of 480 pounds, the ratio and amounts of boneless beef and beef plates to be mixed to yield ground beef patties of various fat fractions were calculated. These data are presented in Table 5.340.

TABLE 5.340 RECIPES FOR VARIOUS STANDARD FAT FRACTIONS IN A 480-POUND BATCH OF GROUND BEEF PATTIES¹

GROUND BEEF FAT FRACTION F_h	WEIGHT OF BONELESS BEEF (lbs.) b	WEIGHT OF BEEF PLATES (lbs.) p	RATIO OF $b:p$ ²
.15	480.	0	All boneless beef
.18	438.8	41.2	11:1
.20	411.4	68.6	6:1
.22	384.	96.	4:1
.24	355.6	124.4	3:1
.50	0	480.	All beef plates

¹Assumes that $F_b = .15$; $F_p = .50$ and $h = b + p = 480$ pounds.

²Rounded to one or two significant figures.

The variation in fat content of the ground beef patties is governed by the variation in the four raw product variables, shown in the following equations:

$$\Delta F_h = \frac{\delta F_h}{\delta p} \Delta p + \frac{\delta F_h}{\delta b} \Delta b + \frac{\delta F_h}{\delta F_p} \Delta F_p + \frac{\delta F_h}{\delta F_b} \Delta F_b$$

and

$$\frac{\delta F_h}{\delta p} = \frac{(F_p - F_b) b}{(p + b)^2}$$

$$\frac{\delta F_h}{\delta b} = - \frac{(F_p - F_b) p}{(p + b)^2}$$

$$\frac{\delta F_h}{\delta F_p} = \frac{p}{p + b}$$

$$\frac{\delta F_h}{\delta F_b} = \frac{b}{p + b}$$

The derivative, ΔF_h , gives the change in fat content as a function of changes in the four different raw product variables. The partial derivatives examine the change in each of the four production variables. Since each independent variable influences the function differently, considering the instantaneous rate of change of the function, it is necessary to isolate the effect of each of the independent variables. When considering how the fat fraction of the ground beef patties changes as the fat fraction of the beef plates change, the other independent raw product

variables must be held constant. The same is true when considering the effects of the other independent variables.

A one percent increase or error in each of the raw product variables was assumed to determine the percent error in the fat fraction of the ground beef patties, F_h . These data are presented in Table 5.341 for a recommended F_h of 22 percent, $F_b = .15$, $b = 384$ pounds, $F_p = .50$ and $p = 96$ pounds. Note that a one percent error in the weight of the boneless beef produces the largest percent error in the fat content. It is, therefore, crucial to know the weights of the two components during the batching operation.

These data illustrate the fact that it is possible to batch process the ground beef patties if the weights and percents fat of the boneless beef and beef plates can be accurately determined. The formula for a specified batch size, with a desirable fat content, can be calculated if the four raw product variables are known. The decision on whether or not to implement this batching procedure is a management determination, which should be made after considering a cost-benefit analysis of the situation.

An added advantage to this batching approach lies in the ability to calculate yields of the raw product. On a given production day, the amount of raw product used to produce the ground beef patties could be calculated. With raw material product cost available, it is possible to calculate the cost to produce a given amount of ground beef patties. These product costs could be used by management

TABLE 5.341 PERCENT ERROR IN THE FAT FRACTION OF THE GROUND BEEF PATTIES DUE TO A ONE PERCENT VARIANCE OR ERROR IN THE INDIVIDUAL VARIABLE¹

PRODUCTION VARIABLE	F_b	b	F_p	p	F_h	PERCENT ERROR IN F_h^2
$\frac{\Delta F_b}{F_b}$	.1515	384	.50	96	.2212	+.55
$\frac{\Delta F_p}{F_p}$	.15	384	.5050	96	.2210	+.46
$\frac{\Delta b}{b}$	.15	387.84	.50	92.16	.2172	-1.27
$\frac{\Delta p}{p}$	.15	383.04	.50	96.96	.2207	+.32

¹Assumes a one percent increase or error in the variable.

²Assumes a target F_h of .22 or 22 percent fat.

to set the prices for the ground beef patties paid by the restaurants.

It is possible to accurately calculate the weight in grams of the ground beef patty, W_h , given the following assumptions: the average fat density, ρ_f , is 0.85 g/cm^3 ; the average lean tissue density, ρ_t , is 1.2 g/cm^3 ; the fixed volume of a patty machine die, V_o , is 40.36 cm^3 ; and the fat fraction of the ground beef patty, F_h . The formula for calculating the weight of the ground beef patty is:

$$W_h = \frac{\rho_f \times \rho_t \times V_o}{\rho_f + (\rho_t - \rho_f) F_h}$$

Then the change in patty weight, ΔW_h , is

$$\Delta W_h = - \frac{\rho_t \times \rho_f}{[\rho_f + (\rho_t - \rho_f) F_h]^2} \Delta F_h$$

If a F_h of .225 is assumed, then the W_h is 44.5 grams. The lowest observed F_h was .19 with a corresponding W_h of 44.91 grams. The maximum value for F_h observed was .248 with a corresponding W_h of 43.94 grams. Therefore, it can be concluded that the variation in the fat content from batch to batch is one of the factors that accounts for the variation in the patty weights. As the fat fraction in a patty increases, the weight of the patty decreases.

This firm cannot consistently produce a 44.5 gram patty without increasing the size of the patty machine die holes. If the firm cannot control the fat content in a batch, they cannot control the weight of the patty either

because of the fixed volume patty being produced. If the batch is not well-mixed, the average fat content may vary from one to two percent from patty to patty.

5.4 Microbiological Analysis

Both the raw boneless beef and beef plates were examined using total plate counts (TPCs) as the indicator of microbiological load. The incoming fresh beef was monitored less frequently than the frozen beef due to the finite resource base (time, equipment, and personnel) available. The ground beef patties were analyzed immediately after production to determine the TPCs. On days when the lab staff was extremely busy, only the patties produced within the commissary were plated and counted. No microbiological testing was conducted once the patties were stored in the commissary and shipped to the restaurants. In addition, TPCs were obtained from swab tests on selected sensitive equipment locations during the lab inspector's pre-operation inspection.

5.41 Microbiology of Ground Beef

The spoilage organisms most likely to attack ground beef are the gram-negative Pseudomonads and the lactic acid bacteria (i.e., Streptococci, Leuconostocs, Lactobacilli, and Pediococci). These organisms proliferate well at refrigerated temperatures. Approximately 99 percent of the organisms likely to be in or on ground beef are the gram-negative organisms. The presence of these gram-negative psychrophiles is indicated in ground beef by the

development of a stale, sour odor at refrigerator temperatures.

The surfaces of grinders and equipment may be contaminated with gram-negative psychrotrophs. These organisms are inoculated into the meat when the product comes into contact with these surfaces. Beyond that, other pathogenic organisms (e.g., Staphylococci, Salmonella, Escherichia and Streptococci) may be introduced into the meat from human sources. At higher temperatures, one would expect to find bacteria of the following genera: Bacillus, Clostridium, Proteus, Pseudomonas, Alcaligenes, Micrococcus and Sarcinia. Molds likely to be present at these higher temperatures are Mucor and Penicillium.

5.42 Total Plate Counts

Total plate counts (TPCs) on ground beef give the inspector a clue as to the handling history of the product, the degree of freshness, the state of decomposition, and remaining product shelf-life. In some cases, TPC may reflect the sanitary status of the food product. It must be noted that TPCs are made somewhat untenable as indicators of the hazardous nature of a food due to the fact that only a fraction of the TPCs may represent pathogenic organisms.

In some instances, it is possible to enumerate low TPCs from a food product that carries a toxin. The toxin-producers may have reproduced and formed their toxins and died as a result of unfavorable conditions. This toxin may remain stable in an environment that does not favor

the continued survival of the vegetative cells. Beyond that, it is virtually impossible to correlate the appearance of the meat with the number of microorganisms present. Meat that is green in color may have undergone a pigment change caused by relatively low numbers of microaerophilic lactics. The TPCs and the gram-negative counts may both be relatively low in these products.

TPC may be a better indicator of the overall sanitation program effectiveness than an indication of the condition of a food product. Since psychrophiles are most likely to influence flavor and odor changes in ground beef, a better indication of the sanitary quality of these food products may be the number of psychrophiles present. These psychrophiles can be responsible for adverse flavor and odor changes in the product. The enumeration of psychrophiles is basically the same procedure as that used for TPCs with the exception that the incubation conditions are 41° to 45°F (5°-7°C) for five to 7 days, rather than 90°F (32°C) for 48 hours. It is possible to infer that, if these psychrophile counts reach the range of 10^7 organisms per gram, some of the customers will be able to detect off-flavors and odors in the ground beef patties.

The data show that the TPCs have increased nearly a 100-fold during the time that the product spends in the commissary. The unanswered question is where this contamination comes from. It behooves the management to identify the sources of contamination and the specific types of

microorganisms involved. Once identified, action can be taken to reduce these unacceptable increases.

5.43 Incoming Product Testing

It is not possible to improve the quality of a product by the inspection process. If the quality factor is not present initially, it is highly unlikely that the quality can be added to the product during processing. In relation to QA/QC inspections, it is better to eliminate a defective or nonconforming product as early as possible before additional resources are spent processing the unacceptable product. That is the goal of incoming product testing.

In a situation where resources are limited, the testing of the income products should remain a high priority. Coupled with a tagging system that maintains product traceability, all incoming products must be sampled, evaluated and tested to determine conformance to the established product specifications. In addition to temperature checks, incoming raw fresh and frozen beef should be examined for fat content, odor, appearance (e.g., dehydration) and microbiological load.

The ICMSF has recommended sampling plans to compensate for the variability in bacterial populations between subsamples. These sampling plans generally improve the reliability of the microbiological results. A sampling plan is basically a statement of the acceptance criteria applied to a lot of food products based upon recommended

examination of a specific number of sample units by designated methods. The sampling plan consists of the following specifications: the number of sample units, n , from a lot that must be examined; the maximum acceptable or allowable number of sample units, c , that may exceed the microbiological criterion; the maximum number or level of relevant bacteria per gram, m ; and the number, M , that indicates the unacceptable quantity relative to either spoilage potential, health hazards, or sanitary indicators.

The sampling plans presented in Table 4.720 detail the specifics for incoming beef. The three-class plan is specified for chilled and frozen meat TPCs. This three-class plan is desirable where count or concentration of organisms are important. This plan is less affected by nonrandom variations between sample units. In addition, a three-class plan is able to measure the frequency of the values in the m to M range and alert management as to marginal products. The two-class sampling plan is recommended for Salmonella testing on the incoming beef because presence/absence tests are desirable.

It is suggested that the commissary lab staff use these sampling plans as a part of the complete inspection of incoming beef products. Coupled with product temperature determinations, these sampling plans approach the product accept/reject decisions in a logical and objective manner. No product should be processed in the commissary before it is deemed acceptable by trained QA/QC personnel.

Such a management policy will minimize problems with unacceptable products discovered too late in the production sequence. The earlier a defect is detected, the more money the organization can save.

5.44 Finished Product Testing

The recommended sampling plan for nonfrozen ground beef was taken from a proposed Canadian standard. Table 4.720 details the specifics of this sampling plan for both TPCs and Salmonella. Inadequate cooking of nonfrozen ground beef patties may permit the survival of Salmonella. Beyond that, the organisms may be spread from raw to cooked meat via the hands of foodhandlers, equipment, utensils, and food contact surfaces. This cross-contamination may occur after the product has been adequately cooked.

It is recommended that the commissary QA/QC regularly inspect each day's production of ground beef patties utilizing the specifics of this sampling plan. The lab staff does not now monitor Salmonella in the finished patties and there is no special reason to recommend that they do. Most, if not all, of the Salmonella present in the raw ground beef patties will be destroyed during the cooking process. In addition, finished products should be examined periodically for psychrophile counts, no less than once a week. These psychrophile counts are perhaps most important when evaluating products that have been stored for one or two days in the commissary walk-in refrigeration unit. Finished products held refrigerated in the individual restaurants should

also be analyzed for psychrophilic activity. At random, a restaurant should be selected each week to ship a five-pound field sample of the oldest ground beef patties in storage back to the commissary. This field sample can be delivered to the commissary aboard the returning company-owned truck and evaluated for psychrophilic load, odor, appearance, and flavor by the QA/QC staff. Over time, an estimate of the normal expected shelf-life of the products can be obtained.

5.45 Equipment Swab Tests

The Pareto principle and analysis offered a rational and objective approach to the investigation of bacterial populations on sensitive equipment locations. The modified evaluation procedure resulted in a system that simplified the analysis and provided more useful information. Increased communication flow between QA/QC staff and the sanitation crews permitted a more intensive cleaning and sanitizing effort.

Even though the modified scheme was successful in reducing the amount of contamination added by meat room equipment, the sanitation effort still has a long way to go. With a maximum attainable score of 143, the score increased from 69.5 to 89.5 during the six week study. Even though improvement was realized, additional improvement is still possible and, no doubt, desirable. This additional improvement can take place if the priority ranking system remains in effect.

Once all 24 swab sites score a priority ranking of 3, each site will be swabbed once each 4 periods (2 weeks). If a swab site scores less than 3, it again becomes high priority. This system will be effective only if the commissary staff continues to use it. Recall that, in the past, there was no systematic evaluation and far too many swab sites yielded too numerous to count (TNTC) results.

One comment made by a lab staff member during the six-week study was that the procedure required an additional 20 to 30 minutes a week compared to the old system and therefore, was undesirable. Whether the additional time is beneficial, in terms of the results, is a management decision based on a cost-benefit analysis. If the benefits exceed the costs, management should require the lab staff to use the modified scheme because it is proven effective.

It is recommended that the cutting knives and boards be added permanently to the list of sensitive locations to monitor. During this investigation, a member of the QA/QC staff made the point that there is a difference in cleanability between stainless steel and plastic surfaces. That being the case, it may be necessary to use a more concentrated solution of sanitizer on the plastic surface to increase the effectiveness. Whenever it is discovered by checking the Alert Sheet that the sanitation effect on plastic surfaces (e.g., conveyor belts and cutting boards) is ineffective, the QA/QC staff should recommend to management that the sanitation crew's efforts need to be evaluated,

or that the plastic surfaces need to be replaced. Management can effectively use the equipment swab tests as a measure to indicate how well the sanitation crew is accomplishing its objectives.

5.46 Employee Swab Tests

Periodically, no less than once a month, it is recommended that skin swabs be taken of commissary production employees. These results will permit the QA/QC staff to determine the human potential for contamination of ground beef patties. In addition, the QA/QC staff might, as part of the regular restaurant inspection, swab food surfaces, refrigerated storage areas, equipment, preparers, and servers. This testing would obviously be scheduled less frequently due to present staff limitations.

5.5 Nutrition Considerations

The nutritional profile of the ground beef patties was estimated using values from the U.S. Department of Agriculture Handbook No. 456. Recommended Daily Dietary Allowances (RDA) for the 23 to 50 year age group were used to determine the Index of Nutritional Quality (INQ). The INQ is an expression of the nutrient density of a food. It is the relationship between the extent to which a food meets the requirement for a specific nutrient compared to the extent it meets the needs for energy for an individual.

5.51 Index of Nutritional Quality

The ground beef patties are considered to be a source of protein, phosphorus, iron, and riboflavin for both males

and females in the 23 to 50 age group. In addition, the product is considered to be a source of niacin for males only. The ground beef patties are considered to be a good or excellent source of protein and phosphorus for both males and females and iron for males only. What remains to be considered is the effects of each of the process flow steps on each of these specific nutrients.

5.52 Nutrient Retention in Meat

If nutrient retention was the only basis for process evaluation, the choice of which process to use might be a relatively simple one. Nutrient retention is only one of the many considerations in food processing compounded by the fact that individual nutrients exhibit unique degradation rates. In addition to nutrient retention, the food product pH, color, flavor, texture and microbial load must be taken into consideration. Each process flow step under consideration might affect the specific nutrients in different ways.

Some losses of nutrients already will have occurred before the product reaches the commissary, the extent of which depends on the types of foods purchased. Regarding nutrient retention, the most important aspect of food receiving is to store the product as soon as possible after delivery by the supplier. This procedure will minimize exposure to the temperature danger zone and the thawing and subsequent refreezing of frozen products. Losses of specific nutrients during storage may take place if such

variables as temperature, humidity, time, and light are not controlled. Generally, fluctuating freezer temperatures have a more adverse effect on texture and flavor than on nutrient retention.

Storage losses, in some cases the result of improper packaging, have a less substantial influence on nutrient retention than do the various stages of the preparation of animal products (including thawing, trimming, cutting, grinding, and forming). Thaw losses during the defrosting of frozen meats may be of major concern. The major losses of vitamins and, to a lesser degree, minerals, from foods often occur during the final preparation in the foodservice operation prior to consumption. Nutrient losses may occur in all forms of cooking as a result of the application of heat and other factors such as drip loss and leaching. These losses are directly influenced by the type of cooking method utilized. Meat cooked on a griddle retains more protein (i.e., less drip loss) than meats cooked with moist heat.

The major sources of nutrient losses during the preparation and service of animal products are: thaw drip, especially from comminuted meats; cooking drip; nutrient leaching; heat losses, and excessive hot holding of cooked foods. The specific nutrient losses are influenced by the nutrient profile of the food product and the extent of processing, storing, heating, and holding. Minerals are generally more stable than vitamins under conditions of

handling and processing, and losses are negligible provided that losses by physical means (e.g., leaching, thaw exudate) are avoided. Protein nutritive values are generally not substantially affected during handling, processing, and distribution.

5.53 Retention of Specific Nutrients

The proteins in beef are considered to be high quality nutrients due to the types and amounts of amino acids present. Meat proteins are classified as complete proteins because they contain all of the essential amino acids in the proportions needed by the body. Cooking of meat begins the breakdown of collagen due to partial hydrolysis. Cooking also enhances digestibility and palatability of meat proteins. There is little or no nutritive quality change in the beef proteins as indicated by monitoring the tryptophan, methionine, and lysine availability during cooking and processing methods (Smith and Minor, 1974). Little, if any, of the essential amino acids in meats are destroyed during processing and cooking. Maximum cooking losses range from a low of 5 percent for phenylalanine to a high of 40 percent for lysine (Livingston et al., 1973). Generally, the amino acids and proteins present in meats are not significantly altered by pH changes, air or oxygen, or light.

Phosphorus is a macromineral that is widely distributed in foods. In general a diet with an adequate protein intake also provides adequate amounts of phosphorus. This is true because phosphorus is a component of most proteins.

The phosphorus content of beef is not significantly altered during storage, processing, or cooking because the mineral is relatively stable to pH, oxygen, light and heat. Maximum losses are expected not to exceed three percent (Guthrie, 1979).

Iron is present in foods in both the heme and nonheme form. Heme iron is the form found in blood and muscle tissue; therefore, this is the form present in beef. The heme form of this micronutrient is highly available and not affected by the composition of the diet. The nonheme form, found in cereals and vegetables, is less readily available and absorbed. Meats improve the body's absorption of nonheme iron. The absorption of iron depends on its availability, as well as the combination of foods eaten. Beef is a relatively good source of iron because muscle tissue contains myoglobin, an iron containing pigment linked with a protein. Cooking losses of iron only occur in discarded cooking water and, therefore, a substantial portion of the iron in meats will be retained. Iron is not significantly destroyed by pH, oxygen, light or heat and the retention is likely to be approximately 97 percent (Guthrie, 1979).

Riboflavin is a relatively stable member of the B group of vitamins. This nutrient is unaffected by acids, oxidation and heat; however, it is inactivated by alkalis and light. Since riboflavin is only slightly soluble in water, it will not be affected substantially by the processing stages associated with the production of the ground

beef patties.

Niacin exists as nicotinic acid (niacin) and nicotinamide (niacinamide) in foods. This B vitamin is extremely stable to acids, alkalis, light, oxidation and heat. Little of this nutrient will be lost during the normal procedures of food processing and preparation. The essential amino acid, tryptophan, is converted into niacin in the body. Beef is an excellent source of protein and niacin due, in part, to this conversion.

This analysis concentrated only on those nutrients in beef classified by the INQ procedure as sources or good or excellent sources. A discussion of other nutrients (e.g., thiamin) was omitted since none fulfilled the INQ criteria. As evidenced by the stability of these specific nutrients, it is highly unlikely that the ground beef patties would drop from sources to poor sources during the processing and preparation procedures employed. For example, to drop from a good or excellent source of protein to a source of protein for males, the precooked ground beef patty weight must be decreased from a total of 88.6 grams to approximately 25 grams. Similarly, the precooked weight must drop to approximately 27 grams to become merely a source of protein for females. As long as reasonable care is practiced, the ground beef patties should retain their INQ status.

The nutrient profile of the ground beef patties is a marketplace quality issue. If the target market is interested in obtaining more nutritious foods in this firm's

restaurants, it is management's responsibility to respond with products that meet or exceed the market's expectations. Ultimately, the extent to which an organization provides nutritious food choices and nutrition information is directly influenced by the desires of their target market. The trends in the United States indicate an increased nutrition awareness. However, it cannot be assumed that this firm's target market strictly follows those trends. Marketing intelligence can provide information regarding how interested this firm's clientele is in obtaining nutritious menu items.

5.6 Sensory Evaluations

Sensory evaluations can be some of the most important QA/QC tools used to evaluate product quality. To be effective, these evaluations must be based on the sensory guidelines and specifications approved by management and conducted by trained personnel. Sensory evaluations should take place during all stages of product flow, from incoming raw material inspections through finished product preparation and service in the restaurant. Sensory analysis can be an effective part of the corporate strategic quality plan if the organization has well-defined sensory quality standards. These standards must be based on the needs and wants of the target market. The firm's sensory evaluation program should be examined on a regular basis to determine its benefit and effectiveness to both the organization and its target market.

5.61 Commissary Sensory Evaluations

Incoming inspections of fresh and frozen beef represent the necessary first step in controlling the quality of the finished product. Sensory evaluations are one of the criterion for QA/QC commissary staff incoming product accept/reject decisions. These inspections should focus on the product's odor and appearance. If the delivered beef has an off-odor, it is unacceptable. If the beef shows evidence of freezer burn or other unusual appearance, it is a likely candidate for rejection.

The objective of incoming product sensory evaluations is to minimize the likelihood that defective or nonconforming products will be processed for sale. In addition to product sensory tests, the supplier's delivery truck should also be checked for signs of contamination and infestation. These inspections can only occur on a regular basis if the receiving function is a planned and organized effort. Commissary QA/QC staff should be notified in advance of product delivery so the necessary inspections can be scheduled and performed. The sensory evaluations of incoming products will provide QA/QC personnel with information to be used to compare the product quality to the established specifications. When a product is determined to be outside of these specifications, it is rejected and the supplier is informed of the reason.

Sensory evaluations are an important part of the determination of in-process product quality as well.

Storage areas for raw materials and finished products should be checked daily for signs of product spoilage, unacceptable storage conditions, and contamination. Both trained production employees and supervisors can use their senses of sight, smell, and touch to evaluate the beef sensory quality during processing. These investigations must be based upon the specifications approved by management. These standards and specifications form the basis for the sensory evaluations by both employees and QA/QC staff members.

The last chance to identify product nonconformance to standards before shipping to the restaurants is the finished product inspection. Finished product inspection should be based upon evaluations of the ground beef patty texture, color, odor, and taste. In-plant sensory panels, consisting of trained and selected employees, should conduct routine product evaluations. These routine taste panels will also provide an audit of the effectiveness of the incoming and in-process evaluations. These taste panels are not to be utilized to establish marketplace quality, as this can be determined only by the target market. The purpose of these taste panels is to examine the finished product in relation to the specifications established by management based on the target market's desires.

5.62 Restaurant Sensory Evaluations

Incoming beef patties delivered to the restaurant should be examined by a trained and selected employee during the receiving inspection. Product sensory characteristics

of odor, appearance, and flavor should be used as the basis for accept/reject decisions. The trained and selected employee should use established specifications to determine whether the ground beef patties are fit for preparation and service to the customers. In addition, a sensory evaluation of the delivery truck should be a regular part of the receiving routine.

Products should also be monitored during storage to minimize losses due to spoilage and contamination. Before being cooked, the ground beef patties should be periodically evaluated for odor and appearance. Once prepared and assembled, a final product inspection must take place by both the cook and the service person to determine whether the product meets the established specifications. No product should be served to the customer that does not meet these management quality criteria.

Periodically, restaurant personnel must be encouraged to taste all products served in the operation. These product tastings can be a regular part of the restaurant's employee meetings. The objective of these product tastings is to familiarize the preparation and service personnel with the product so that they can intelligently provide information to customers during personal selling contacts. In addition, these product tastings demonstrate management's interest in maintaining quality and employee involvement and interest. They provide the impetus for monitoring product quality in the restaurants.

The firm's clientele should be encouraged to make comments regarding the operation's food quality. These comments must be communicated to management so that action can be taken if a problem is identified. Fundamental to the success of sensory evaluations of food products is the establishment by management of standards and the training of personnel to carry out the investigations. Management must realize that they cannot be in all places at all times to evaluate the product sensory status. Therefore, management must rely on the efforts of trained employees if the program is to be successful.

The organization's management should recognize that the goal of product sensory evaluations is to provide information regarding the firm's quality efforts. Sensory evaluations of products should be an integral part of the operation's strategic quality plan. The mission of any service organization is to satisfy the needs and wants of its target market at a profit. Once these needs are determined and product specifications are established, sensory evaluations provide information regarding how well the organization is progressing toward satisfying these needs. Sensory evaluations, coupled with the other QA/QC tools described, are an essential part of the corporation's strategic quality plan geared toward achieving the firm's stated mission.

5.7 Product Recall Procedures

The objective of establishing recall procedures is to have a specified action plan in the event that defective or

nonconforming products are shipped from the commissary. The recall plan establishes a strategy and specifies the procedures to be followed when it becomes necessary to recall any products that are no longer under the control of the commissary. The plan will be activated whenever the situation dictates that a recall is essential. The goal is to have an established, well-planned system for handling recalls beforehand rather than reacting to situations in a pillar-to-post or firefighting style of management.

5.71 Statement of the Recall Plan

The primary advantage to a well-developed recall plan is that it permits management to be proactive rather than reactive. Recall plans are a strategy for anticipating problems before these problems surface. A statement of the organization's recall plan should appear in the corporate strategic quality plans. One individual in the organization should be designated as the corporate recall officer, and be primarily responsible for implementing the plan and coordinating all of the firm's resources necessary to successfully accomplish the recall. Once the recall is initiated, the firm's recall officer must advise the appropriate health officials regarding when the recall was started, the specific reasons for the recall, and the organization's recall strategy.

5.72 Product Traceability

Fundamental to the success of any recall is the capability for identifying and tracing the distribution of the

product under recall. The system of tagging meat products at the time of receipt would begin this scheme of product traceability. A product tag should be developed that is capable of recording the following information: the product name, the supplier, the date received by the commissary, the processing date, and the date of receipt by the restaurant. This tag would be affixed to all incoming meat items and remain with the item until the product is consumed in the restaurant. This tag would be checked and initialed at the time of commissary receipt, commissary processing, and restaurant receipt by the individual in charge of each operation.

5.73 Responsibilities of the Organization

In addition to providing the recall plan and establishing a system for product traceability, the firm's management has other responsibilities related to product recall. The appropriate health officials must be notified promptly when a product is being removed or a deficiency is being corrected, and provided with sufficient details. Under no circumstances should management be a party to either overt or covert cover-ups of defective products.

Management also bears the responsibility of initiating a recall when requested to do so by the proper health authorities. In addition, management is accountable for developing and adhering to its recall strategy and taking the necessary action to guarantee that the recall is effective. Management is liable to notify all restaurant owners and managers

involved in the product recall. Product traceability again surfaces as the key component in a successful recall plan.

Management is also responsible for evaluating the circumstances that precipitated the recall and prescribing measures to prevent a recurrence. Beyond that, management must provide the health authorities involved with periodic progress reports regarding the status of the recall. When the recall has been completed, management should submit a report to the appropriate health officials, detailing the extent of effectiveness of the recall and the fate of the recalled products. It is management's responsibility to define, in writing, the specific functions of the QA/QC staff and facilities related to the recall procedure.

5.8 Quality Audits

A quality survey or audit is a feedback tool to determine the effectiveness of the organization's efforts in meeting the strategic quality plan. The audit covers the product and the QA/QC system. The quality survey should be scheduled on a regular basis to provide information that will enable management to fine tune the system. Quality audits measure the extent to which management is effective and efficient. Special quality audits may be undertaken as a result of the surfacing of symptoms of a specific quality problem. Quality audits are similar to accounting audits in the sense that the objectivity of reporting is more likely to be achieved when the auditors are organizationally

independent of the area under investigation. Quality audits evaluate the product, inspection personnel, and the system for achieving and maintaining product quality.

5.81 Comprehensive Quality Audits

A comprehensive quality audit entails obtaining information from a number of sources. The needs and wants of the target market should be examined to determine the adequacy of corporate product specifications to meet these desires. The detailed, written purchase specifications are evaluated in terms of the supplier's ability to meet the specifications and the firm's ability to monitor whether or not these specifications are being followed. Manufacturing specifications are investigated to decide whether they are in line with the organization's mission. Customer quality complaints are categorized to review the nature of these complaints and the adequacy of corrective action.

The performance of all QA/QC personnel is also reviewed. An investigation is undertaken to determine the adequacy of QA/QC equipment and facilities, testing, sampling and inspection procedures and decision-making processes. The audit also includes an evaluation of the estimates of quality costs and other relevant information provided to corporate management to review the organization's quality performance. In addition, the focus of the firm's quality program is investigated to ascertain whether the personnel involved are taking the necessary steps to

satisfy the quality desires of the target market.

Comprehensive quality audits are time-consuming and they can be expensive. However, the investigation can certainly be justified on the basis of cost-benefit analysis. Minimally, a management review of the comprehensive quality audit should focus on the "vital few" product quality characteristics. This Pareto approach to the quality audit procedure can involve a sampling inspection of the firm's products, inspection procedures, and system for achieving and maintaining product quality.

5.82 Special Quality Audits

Special quality audits are required when a particular problem surfaces in the organization. For example, a special quality audit would be initiated if customer quality complaints increase dramatically. In foodservice, the outstanding example of an external failure is the customer complaint. The firm's customers can provide useful information regarding their perceptions of the corporation's emphasis on meeting their quality expectations. To be effective, a specific person in the organization should be in charge of monitoring and following up all customer complaints.

All complaints should be classified and indexed according to the nature of the problem. This indexing will permit the customer complaint officer to analyze the data for trends in quality deviations. All customer complaints should be acknowledged promptly and properly evaluated. Corrective action should be a part of this complaint

procedure. The customer complaint officer should make a conscientious attempt to obtain information from the complainant regarding the facts of the case. The date of the incident, the product, the store location, and the time would all be relevant facts to determine. The store manager should also be contacted to obtain other information regarding the incident under investigation.

After the complaint has been registered, corrective action is required. This corrective action might include an explanation to the complainant, a denial of liability, a product offered at no expense (e.g., a free meal or gift), and/or a monetary settlement. The nature of the corrective action is dictated by the type of complaint. The corporate customer complaint officer should be authorized to resolve the complaint to the customer's satisfaction, based on established policies and guidelines.

When customer complaints surface in the individual restaurants, the restaurant manager should have available a similar set of policies and guidelines. Customer complaints brought to the attention of the restaurant manager should be dealt with at that level and rectified promptly and properly. All restaurant employees should be encouraged to report customer complaints to the management of the individual unit. This action will minimize the extent to which the corporate customer complaint officer interferes with management's responsibilities in the restaurants.

The resolution of customer complaints should take a high priority in a foodservice firm's operating procedures. Since foodservice firms are service-oriented businesses, they live or die based on satisfaction of the needs of the target market. To remain viable and profitable, foodservice organizations should realize that the primary mission of the corporation is the fulfillment of their clientele's needs. Employees, as representatives of the corporation's strategic quality plan, must be aware of the significance of this mission.

5.9 Conclusions and Recommendations for Additional Research

The thrust of this research was an analytical and comprehensive investigation of ground beef patty production in a commissary foodservice system. Several QA/QC tools were used to evaluate the effectiveness of this firm's total quality system. The HACCP procedure revealed deficiencies in the system and pointed the way toward corrective action. The costs of quality and the management responsibilities regarding QA/QC were discussed in a general sense. The Pareto analysis focused the QA/QC efforts on the "vital few" sensitive locations in the commissary meat production room.

The ground beef patty weights were analyzed to determine uniformity. A process capability study and analysis revealed the extent to which the patty weights conform to the corporation's established tolerances. Recommendations

were developed based on the information resulting from the ground beef patty weight investigations.

Microbiological analyses of both incoming beef and finished ground beef patties determined the extent of product contamination. Recommendations to reduce the contamination and monitor the product's bacterial load were presented. The ground beef patty nutrient profile was studied to ascertain its contribution to daily nutritional needs. Commissary sensory evaluations were evaluated and recommendations were made regarding the use of sensory taste panels and sensory analysis in both the commissary and restaurants.

Suggestions were developed in regard to product recall procedures. Guidelines for initiating a system for product traceability in both the commissary and restaurants were discussed. The topic of quality audits was amplified in relation to comprehensive and special quality surveys. A system for classifying and handling customer complaints was developed.

The objective of this research was to provide the management of this commissary foodservice system with an independent study of their quality program. Several of these recommendations can be adapted to any foodservice system, regardless of size. The decision whether or not to incorporate these recommendations is, obviously, a decision that can be made only by the management of this foodservice system. The recommendations presented allow management to be proactive rather than reactive.

Management of any foodservice organization should be committed to satisfying the quality desires of the target market. Management must realize that a total corporate commitment to quality, value and service is necessary to attract new customers and repeat sales. A corporate strategic quality plan involves more than a clever marketing slogan regarding statements about the firm's quality emphasis. The real problem with maintaining food safety and QA/QC programs is management, or the lack of it.

Management must realize that predictability is the key to success. The primary responsibility of management is centered on the development of a quality product and image coupled with a strong identity and a solid, consistent marketing effort to increase market share. Those foodservice corporations that are the "shakers and movers" and are today on the lead, or cutting edge, of tomorrow recognize the value of employee motivation regarding quality. In the final analysis, the integrity of management and the quality of employees comprise the competitive edge leading to success in a foodservice operation.

In business, it has been said that timing is everything and that time is money. Applied to a firm's QA/QC emphasis, it can be concluded that it takes time to save money. Management should spend its time in relation to the amount of money that it can save (cost avoidance) in each of the basic operating activities. However, it is not always possible to save money regarding the QA/QC program.

A successful foodservice firm is supported through quality food, attention to detail by the organization's management and employees, and the timeliness of the services provided. Fundamentally, an emphasis on quality is a marketing approach. If the target market's needs and desires can be satisfied at a profit, the foodservice organization is guaranteed success.

Additional research regarding the quality of food prepared and served in foodservice systems is needed. In order to be effective, this research should not be purely empirical, but applied to the specific needs of the foodservice industry. Suggestions for further research based on the conclusions of this study are:

1. An application of the QA/QC tools used in this study to other products produced within this foodservice system.
2. An extrapolation of these research findings to other types of foodservice systems, especially fast food organizations.
3. Additional analysis of the nutritional and sensory attributes that govern the customer's choice of a particular foodservice operation or menu item.
4. An application of the Pareto principle and analysis to other QA/QC problems associated with the foodservice industry, especially customer complaints.

5. Determination and analysis of the costs of quality in this foodservice system.

REFERENCES

- Abrams, I. J. 1978. Determining consumer demand and marketing opportunities for nutritional products. Food Tech. 32(9): 79.
- Angelotti, R. 1975. FDA regulations promote quality assurance. Food Tech. 29(11): 60.
- Anonymous. 1978. Consumer study unveils emergence of new nutrition concepts. Food Prod. Dev. 12(7): 80.
- Anonymous. 1979a. Fast-food chains. Consumer Reports. 44: 508.
- Anonymous. 1979b. Sanitation and safety update. Restaurant Business. 78(15): 125.
- Anonymous. 1980a. Commissary kitchens assailed by costly regulations. NRA Washington Report. 23(11): 2.
- Anonymous. 1980b. Despite problems, new NRA officers anticipate growth, prosperity. NRA News. 19(12): 3.
- Anonymous. 1980c. The market: The "400" posts real growth of 2.3 percent. Institutions. 87(2): 24.
- Anonymous. 1981. NRA predicts small but real growth for 1981. Restaurant and Institutions. 88(2): 8.
- ANSI/ASQC Standard A3-1978. American National Standards Institute, Inc., New York. American Society for Quality Control. Milwaukee, WI.
- Appledorf, H. 1974. Nutritional analysis of foods from fast-food chains. Food Tech. 28(4): 50.
- Appledorf, H. 1979. Nutritious menu design for restaurant operations. Food Tech. 33(3): 38.
- ASTM. 1951. Spec. Pub. 15-C. Quality control of materials. Philadelphia, PA.
- Avery, A. C. 1980. A modern guide to foodservice equipment. CBI Pub. Co. Boston, MA.

REFERENCES

- Ayres, J. C. 1969. Practical control of salmonellae. J. Milk Food Technol. 32: 126.
- Bauman, H. E. 1974. The HACCP concept and microbiological hazard categories. Food Tech. 28(9): 30.
- Berry, B. W., and Ai-Ti Chen, A. 1976. Bacterial shelf-life and consumer acceptance characteristics of chopped beef. J. Food Prot. 39: 405.
- Bianco, L. J. 1977. Guidelines for a dynamic quality control program in a changing market. J. Food Prot. 40: 423.
- Bobeng, B. J., and David, B. D. 1977. HACCP models for quality control of entree production in foodservice systems. J. Food Prot. 40: 632.
- Bobeng, B. J., and David, B. D. 1978a. HACCP models for quality control of entree production in hospital foodservice systems. I. Development of hazard analysis critical control point models. J. Amer. Dietet. Assoc. 73: 524.
- Bobeng, B. J., and David, B. D. 1978b. HACCP models for quality control of entree production in hospital foodservice systems. II. Quality assessment of beef loaves utilizing HACCP models. J. Amer. Dietet. Assoc. 73: 530.
- Bolaffi, A., Tinninghast, E. A., Hoyt, K. J., and Mallery, V. D. 1973. Quality assurance in a franchised food industry. Food Tech. 27(8): 24.
- Briskey, E. J. 1978. Management's view of quality assurance--aspirations and requirements. Food Tech. 32(10): 43.
- Bryan, F. L. 1968. What the sanitarian should know about staphylococci and salmonellae in non-dairy products. II. Salmonellae. J. Milk Food Technol. 31: 131.
- Bryan, F. L. 1978a. Factors that contribute to outbreaks of foodborne disease. J. Food Prot. 41: 816.
- Bryan, F. L. 1978b. Impact of foodborne diseases and methods of evaluating control programs. J. Environ. Health. 40: 315.
- Bryan, F. L. 1979. Prevention of foodborne diseases in foodservice establishments. J. Environ. Health. 41: 198.
- Bryan, F. L. 1980. Foodborne diseases in the United States associated with meat and poultry. J. Food Prot. 43: 140.
- Bryan, F. L. 1981. Hazard analysis of foodservice operations. Food Tech. 35(2): 78.

- Bryan, F. L., Harvey, M., and Misup, M. C. 1981. Hazard analysis of party-pack foods prepared at a catering establishment. *J. Food Prot.* 44: 118.
- Bryan, F. L., and McKinley, T. W. 1974. Prevention of foodborne illness by time-temperature control of thawing, cooking, chilling, and reheating turkeys in school lunch kitchens. *J. Milk Food Technol.* 37: 420.
- Bryan, F. L., and McKinley, T. W. 1979. Hazard analysis and control of roast beef preparation in foodservice establishments. *J. Food Prot.* 42: 4.
- Bryan, F. L., and McKinley, T. W. 1980. Hazard analysis and control of roast beef jus preparation in foodservice establishments. *J. Food Prot.* 43: 512.
- Bryan, F. L., McKinley, T. W., and Mixon, B. 1971. Use of time-temperature evaluations in detecting the responsible vehicle and contributing factors of foodborne disease outbreaks. *J. Milk Food Technol.* 34: 576.
- Bryan, F. L., McNaught, K., and Blehm, K. 1980. Time-temperature survey at a restaurant that specializes in barbecued food. *J. Food Prot.* 43: 595.
- Bryan, F. L., Seabolt, K. A., Peterson, R. W., and Roberts, L. M. 1978. Time-temperature observations of food and equipment in airline catering operations. *J. Food Prot.* 41: 80.
- Bryan, F. L., Smith, J. D., and McKinley, T. W. 1980. Hazard analysis of frozen dinners prepared at a catering establishment. *J. Food Prot.* 43: 608.
- Carl, K. E. 1975. Oregon's experience with microbiological standards for meat. *J. Milk Food Technol.* 38: 483.
- Center for Disease Control. 1977. *Salmonella surveillance*. CDC. Atlanta, GA.
- Center for Disease Control. 1978. *Foodborne disease surveillance*. CDC. Atlanta, GA.
- Center for Disease Control. 1980. Human salmonella isolates--United States, 1979. *Morbidity Mortality Weekly Rep.* 29: 189.
- Chambers, J. V., Brechbill, D. O., and Hill, D. A. 1976. A microbiological survey of raw ground beef in Ohio. *J. Milk Food Technol.* 39: 530.

- Chem, L., and Lachance, P. A. 1974. An area of concern: The nutritive profile of fast-food meal combinations. Food Prod. Dev. 8(8): 40.
- Childers, A. B., Keahey, E. E., and Vincent, P. G. 1973. Sources of salmonellae contamination of meat following approved livestock slaughtering procedures. II. J. Milk Food Technol. 36: 635.
- Chipley, J. R., and Cremer, M. L. 1980. Microbiological problems in the foodservice industry. Food Tech. 34(10): 59.
- Cichy, R. F. 1980. Nutrition--an emerging trend in food-service operations. The Consultant. 13(6): 21.
- Clausi, A. S. 1979. Revising the U.S. food safety policy: An industry viewpoint. Food Tech. 33(11): 65.
- Cohen, M. L., and Blake, P. A. 1977. Trends in salmonellosis outbreaks: 1963-1975. J. Food Prot. 40: 798.
- Cordell, V. E. 1974. Charting a safeness course for the foodservice industry. J. Milk Food Technol. 37: 177.
- Cremer, M. L., and Chipley, J. R. 1977. Satellite food-service systems: Time and temperature and microbial and sensory quality of precooked frozen hamburger patties. J. Food Prot. 40: 603.
- Cremer, M. L., and Chipley, J. R. 1979. Time and temperature, microbiological and sensory quality of meat loaf in a commissary foodservice system transporting heated food. J. Food Sci. 44: 317.
- Crespo, F. L., and Ockerman, H. W. 1977. Thermal destruction of microorganisms in meat by microwave and conventional cooking. J. Food Prot. 40: 442.
- Cross, H. J., Nichols, J. E., and Kotula, A. W. 1980. Effect of grinding method on textural properties of cooked ground beef. J. Food Prot. 43: 555.
- Curtis, J. E., and Huskey, G. E. 1974. HACCP analysis in quality assurance. Food Prod. Dev. 8(3): 24.
- Dahl, C. A., and Matthews, M. E. 1980. Cook/chill food-service system with a microwave oven: Thiamin content in portions of beef loaf after microwave heating. J. Food Sci. 45: 608.

- Dahl, C. A., Matthews, M. E., and Marth, E. H. 1978. Cook/chill foodservice systems: Microbiological quality of beef loaves at five process stages. J. Food Prot. 41: 788.
- Darrah, R. M. 1974. A quality control program for the food industry. J. Milk Food Technol. 37: 42.
- Defigueiredo, M. P., and Splittstoesser, D. F., Eds. 1978. Food microbiology: Public health and spoilage aspects. Avi Pub. Co., Inc. Westport, CN.
- Duitschaever, C. L., Arnott, D. R., and Bullock, D. H. 1973. Bacteriological quality of raw refrigerated ground beef. J. Milk Food Technol. 36: 375.
- Duitschaever, C. L., Bullock, D. H., and Arnott, D. R. 1977. Bacteriological evaluation of retail ground beef, frozen beef patties, and cooked hamburger. J. Food Prot. 40: 378.
- Emswiler, B. S., and Kotula, A. W. 1979. Bacteriological quality of ground beef prepared from hot and chilled beef carcasses. J. Food Prot. 42: 561.
- Enderwood, B. 1980. Fast food's nutritional potential. Restaurant Business. 79(5): 164.
- Engler, P. P., and Bowers, J. A. 1976. B-vitamin retention in meat during storage and preparation. J. Amer. Dietet. Assoc. 69: 253.
- Erdman, J. W. 1979. Effect of preparation and service of food on nutrient value. Food Tech. 33(2): 38.
- Fennema, O. 1977. Loss of vitamins in fresh and frozen foods. Food Tech. 31(12): 32.
- Field, R. A., Smith, F. C., Deane, D. D., Thomas, G. M., and Kotula, A. W. 1977. Sources of variation at the retail level in bacteriological condition of ground beef. J. Food Prot. 40: 385.
- Food and Drug Administration. 1976. Bacteriological analytical manual for foods. Assoc. of Official Analytical Chemists. Washington, D.C.
- Foster, J. F., Fowler, J. L., and Ladiges, W. C. 1977. A bacteriological survey of raw ground beef. J. Food Prot. 40: 790.
- Foster, J. F., Guthertz, L. S., Hunderfund, R. C., and Fowler, J. L. 1978. Comparison of bacterial species isolated from ground beef, textured soy protein, and ground beef extended with textured soy protein. J. Food Prot. 41: 961.

- Foster, E. M., and the Committee on Salmonella, National Academy of Sciences--National Research Council. 1970. An evaluation of the salmonella problem: summary and recommendations. J. Milk Food Technol. 33: 42.
- Fruin, J. T. 1978. Microbiological criteria for food. J. Food Prot. 41: 481.
- Gill, J. L. 1978. Design and analysis of experiments in the animal and medical sciences. Vol. 1. Iowa State Univ. Press. Ames, IA.
- Goodfellow, S. J., and Brown, W. L. 1978. Fate of salmonella inoculated into beef for cooking. J. Food Prot. 41: 598.
- Gould, W. A. 1977. Food quality assurance. Avi Pub. Co. Inc. Westport, CN.
- Grant, E. L., and Leavenworth, R. S. 1972. Statistical quality control. 4th ed. McGraw-Hill Co. New York, NY.
- Greecher, C. P., and Shannon, B. 1977. Impact of fast food meals on nutrient intake of two groups. J. Amer. Dietet. Assoc. 79: 368.
- Guthrie, H. A. 1979. Introductory nutrition. 4th ed. C. V. Mosby Pub. Co. St. Louis, MO.
- Guthrie, R. K. 1972. Food sanitation. Avi Pub. Co. Inc. Westport, CN.
- Hansen, R. G., Wyse, B. W., and Sorenson, A. W. 1979. Nutritional quality index of foods. Avi Pub. Co. Inc. Westport, CN.
- Hauschild, A. H., and Bryan, F. L. 1980. Estimate of cases of food- and waterborne illness in Canada and the United States. J. Food Prot. 43: 435.
- Herrmann, E. C., and Herrmann, J. A. 1978. Concerns, experiences, attitudes and practices of executives of chain foodservice firms regarding quality control procedures. J. Food Prot. 41: 291.
- Hirsh, N. L. 1971. Sensory good sense. Food Prod. Dev. 5(6): 27.
- Hirsh, N. L. 1975. Getting fullest value from sensory panels. Part III: Use and misuse of test panels. Food Prod. Dev. 9(1): 78.
- Holland, G. C. 1979. Quality standards for retail meats. J. Food Prot. 42: 675.

ICMSF. 1974. Microorganisms in foods. Sampling for microbiological analysis: Principles and specific applications. Vol. 2. Univ. of Toronto Press. Toronto, Canada.

ICMSF. 1978. Microorganisms in foods. Their significance and methods of enumeration. Vol. 1. Univ. of Toronto Press. Toronto, Canada.

IFT's Expert Panel on Food Safety and Nutrition and the Committee on Public Information. 1976. The effects of food processing on nutritional value. Food Tech. 28(1): 77.

Ito, K. 1974. Microbiological critical control points in canned foods. Food Tech. 28(9): 46.

Jay, J. M. 1978. Modern food microbiology. 2nd ed. D. Van Nostrand Co. New York, NY.

Juran, J. M. and Gryna, F. M. 1970. Quality planning and analysis. McGraw-Hill Book Co. New York, NY.

Juran, J. M., Seder, L. A., and Gryna, F. M., eds. 1962. Quality control handbook. 2nd ed. McGraw-Hill Book Co. New York, NY.

Karel, M. 1979. Effect of storage on the nutrient retention of foods. Food Tech. 33(2): 36.

Karim, G. 1977. Bacteriological quality of raw and cooked hamburger at the retail level in Tehran. J. Food Prot. 40: 560.

Kauffman, F. L. 1974. How FDA uses HACCP. Food Tech. 28(9): 51.

Knight, J. B., and Kotschevar, L. H. 1979. Quantity food production, planning and management. CBI Pub. Co. Inc. Boston, MA.

Kotschevar, L. H. 1966. Standards, principles, and techniques in quantity food production. 3rd ed. Cahnners books. Boston, MA.

Kotschevar, L. H. 1975. Quantity food purchasing. 2nd ed. John Wiley and Sons, Inc. New York, NY.

Kramer, A., and Twigg, B. A. 1962. Fundamentals of quality control for the food industry. Avi Pub. Co., Inc. Westport, CN.

Kubu, S. 1973. Quality assurance system for a fast-food service chain. Food Tech. 27(8): 30.

- Lachance, P. A. 1973. The vanishing American meal. Food Prod. Dev. 7(9): 36.
- Ladiges, W. C., and Foster, J. F. 1974. Incidence of salmonella in beef and chicken. J. Milk Food Technol. 37: 213.
- Larmond, E. 1973. Physical requirements for sensory testing. Food Tech. 27(11): 28.
- Laughlin, P. E. 1961. Food sanitation and quality control--facts and fallacies. J. Milk Food Technol. 24: 89.
- Ling, R. F., and Roberts, H. V. 1980. Users manual for IDA. The Scientific Press. The Stanford Barn. Palo Alto, CA.
- Livingston, G. E., and Chang, C. M. 1979. Foodservice operation design for nutrient retention. Food Tech. 33(3): 32.
- Livingston, G. E., Ang, C. Y., and Chang, C. M. 1973. Effects of processing, storage and handling on nutrient retention of foods. Effects of foodservice handling. Food Tech. 27(1): 28.
- Longree, K. 1972. Quantity food sanitation. John Wiley and Sons, Inc. New York, NY.
- Longree, K., and Blaker, G. G. 1971. Sanitary techniques in foodservice. John Wiley and Sons, Inc. New York, NY.
- Lund, D. B. 1979. Effect of commercial processing on nutrients. Food Tech. 33(2): 28.
- Lushbough, C. H. 1978. Practical applications of the QA concept in an operating environment. Food Tech. 32(10): 46.
- Main, J. 1980. The battle for quality begins. Fortune. 102(13): 28.
- Marsh, B. T. 1979. Principles of food inspection. J. Food Prot. 42: 180.
- Merolli, A. 1980. Sensory evaluation in operations. Food Tech. 34(11): 63.
- Minor, L. J. 1977. Quality as an economic force in the foodservice industry. The Cornell H.R.A. Quarterly. 18(2): 29.
- Mizer, D. A., and Porter, M. 1978. Food preparation for the professional. Harper and Row Pub. Co. Inc. New York, NY.

- Murray, B. A. 1977. The quality assurance/management interface: Do we speak the same language? Food Tech. 31(10): 26.
- Nakayama, M., and Wessman, C. 1979. Application of sensory evaluation to the routine maintenance of product quality. Food Tech. 33(9): 38.
- National Institute for the Foodservice Industry. 1978. Applied foodservice sanitation. 2nd ed. D. C. Heath and Co. Chicago, IL.
- Nickerson, J. T., and Sinskey, A. J. 1972. Microbiology of foods and food processing. Am. Elsevier Pub. Co. New York, NY.
- Nitzke, W. J., and Christensen, B. 1980. What nutrients are lurking in your burger and fries, and who can prove it? Institutions. 86(9): 87.
- Nitzke, W., and Christensen, R. 1979. Foodservice nutrient information efforts can yield promotional, marketing advantages. Food Prod. Dev. 13(11): 54.
- Pangborn, R. M. 1964. Sensory evaluation of foods: A look backward and forward. Food Tech. 18(9): 63.
- Paul, P. C., and Palmer, H. H. 1972. Food theory and applications. John Wiley and Sons, Inc. New York, NY
- Pearce, J. 1980. Sensory evaluation in marketing. Food Tech. 34(11): 60.
- Peterson, A. C., and Gunnerson, R. E. 1974. Microbiological critical control points in frozen foods. Food Tech. 28(9): 37.
- Pivnick, H., Erdman, I. E., Collins-Thompson, D., Roberts, G., Johnston, M. A., Conley, D. R., Lachapelle, G., Purvis, U. T., Foster, R., and Milling, M. 1976. Proposed microbiological standards for ground beef based on a Canadian survey. J. Milk Food Technol. 39: 408.
- Raffaele, F. J. 1981. Food product safety--the basics. Dairy and Food Sanitation. 1(1): 18.
- Rao, V. N., and Koehler, R. E. 1979. Analysis of some sampling distributions for quality control of foods. J. Food Sci. 44: 977.
- Reece, R. N. 1979. A quality assurance perspective of sensory evaluation. Food Tech. 33(9): 37.

- Richardson, T. 1974. Sanitation for foodservice workers. 2nd ed. CBI Pub. Co. Inc. Boston, MA.
- Riggs, S. 1979. The nutrition battle. Institutions. 85(12): 19.
- Riggs, S. 1980. What you need to know about nutrients. Institutions. 87(1): 22.
- Scala, J. 1978. Responsibilities of the food industry to ensure an optimum diet. Food Tech. 32(9): 77.
- Sharf, J. M., ed. 1966. Recommended methods for the microbiological examination of foods. 2nd ed. Am. Public Health Assoc. Inc. Washington, D.C.
- Shoup, J. G., and Oblinger, J. L. 1976. Microbiological evaluation of retail ground beef: Centralized and traditional preparation. J. Food Prot. 39: 179.
- Skinner, E. 1980. Sensory evaluation in distribution. Food Tech. 34(11): 65.
- Smith, C. G., and Smith, J. D. 1975. Quality assurance systems meets FDA regulations. Food Tech. 29(11): 64.
- Smith, L. L., and Minor, L. J. 1974. Foodservice science. Avi Pub. Co. Inc. Westport, CN.
- Snyder, O. P. 1981. A model foodservice quality assurance system. Food Tech. 35(2): 70.
- Speck, M. L., ed. 1976. Compendium of methods for the microbiological examination of foods. American Public Health Assoc. Washington, D.C.
- Stroud, D. H. 1981. The meat beat. Restaurant Hospitality. 65(1): 71.
- Swaminathan, B., Link, M. A., and Ayres, J. C. 1978. Incidence of salmonellae in raw meat and poultry samples in retail stores. J. Food Prot. 41: 518.
- Swift, L. 1980. Kitchen cleaning starts with planning. Cooking for Profit. July-August. 12.
- Tassan, C. G. 1980. Sensory evaluation in research and development. Food Tech. 34(11): 57.
- Terrell, M. E. 1979. Professional food preparation. 2nd ed. John Wiley and Sons, Inc. New York, NY.

Thorner, M. E., and Manning, P. B. 1976. Quality control in foodservice. Avi Pub. Co. Inc. Westport, CN.

Tiegs, C. L. 1980. Burger Chef--carving out an image. Restaurant Business. 79(3): 158.

Tompkin, R. B. 1976. Detection of salmonellae in foods--past, present and future: Activities and attitudes of the food industry. J. Milk Food Technol. 39: 359.

Turner, J. M. 1979. Putting food safety policy into proper focus. Food Tech. 33(11): 63.

Unklesbay, N. F., Maxcy, R. B., Knickrehm, M. E., Stevenson, K. E., Cremer, M. L., and Matthews, M. E. 1977. Foodservice systems: Product flow and microbial quality and safety of foods. North Central Regional Res. Pub. No. 245, Missouri Agric. Exp. Sta., Columbia, MO

Walker, B., Nuzzi, J., and Beck, R. N. 1978. Accuracy of menus in foodservice establishments. J. Food Prot. 41: 899.

United States Department of Agriculture. 1950. Handbook No. 8. Composition of foods -- raw, processed, and prepared.

United States Department of Agriculture. 1975. Handbook No. 456. Nutritive Values of American Foods.

United States Department of Agriculture. 1977. Home and garden bulletin No. 8.

Weekes, D. 1979. Telling all pays off. Restaurant Business. 78(13): 150.

Weisman, S. 1979. Chains examine distribution methods. Restaurant Business. 78(14): 150.

West, B. B., Wood, L., Harger, V. F., and Shugart, G. S. 1977. Foodservice in institutions. 5th ed. John Wiley and Sons, Inc. New York, NY.

Westhoff, D., and Feldstein, F. 1976. Bacteriological analysis of ground beef. J. Milk Food Technol. 39: 401.

Wilson, E. D., Fisher, K. H., and Garcia, P. A. 1979. Principles of nutrition. 4th ed. John Wiley and Sons, Inc. New York, NY.

Winslow, R. L. 1975. A retailer's experience with the Oregon bacterial standards for meat. J. Milk Food Technol. 38: 487.

Wodicka, V. O. 1977. Quality assurance and the government. Food Tech. 31(10): 20.

Wren, J. J. 1977. Sensory testing as a management tool. In: "Sensory Quality Control: practical approaches in food and drink," H. W. Symons and Wren, J. J., eds., The food group (Sensory Panel) and the society of chemical industries, London.

Wyatt, C. J., and Guy, V. 1980. Relationships of microbiological quality of retail meat samples and sanitary conditions. J. Food Prot. 43: 385.

APPENDICES

APPENDIX A

COMMISSARY PRODUCT EVALUATION FORMS

ACCEPTED _____

REJECTED _____

MEAT RECEIVING

Product _____

Item _____

P.O. Number _____

Date _____

Temperature _____

Pounds/Boxes/Pallets _____

Code/Codes _____

Receiving Department:

1. Random pick 10 boxes from a full truck load, five boxes from 1/2 load or at least three boxes other partial load.
2. Weigh each box and record:

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
3. Staple a white card to each pallet showing P.O. number and date received.
4. Take the same 10 boxes and put outside the lab.
5. Lab personnel will take sterile samples of each box.

A. Results APC per/gm

_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

6. Meat Department will grind all 10 by themselves and take a representative 5 lb. sample to the lab for chemical analysis.

% Fat		% Moisture	
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
Average _____		Average _____	

cc: Lab original
Purchasing
Plant Manager

Comments:

	PATTIES		NOTIFIED	ACTION
	% FAT	WEIGHT		
STANDARD	22%	45.4 gm.		
TIME				

DAILY COMMISSARY SANITATION
MEAT DEPARTMENT

DATE: _____

BY: _____

Circulation
Quality Assurance
Meat Room Manager
Sanitation Manager
Plant Manager
Maintenance Manager
USDA

A - Critical
B - Major
C - Minor
✓ - O.K.

Housekeeping Rated
1 - Excellent
2 - Very Good
3 - Good
4 - Fair
5 - Poor

AREA	DEFICIENCY	ACTION TAKEN
<u>72 RAYTHEON ROOM</u> _____ General Housekeeping _____ Raytheon _____ Interior _____ Exterior _____ Walls _____ Floor _____ Ceiling		
<u>65 PACKAGING/STEAK AREA</u> _____ General Housekeeping _____ Doors _____ Walls _____ Floor _____ Light, Pipes _____ Ceiling _____ Refrigeration Unit _____ Scales _____ Counter _____ Steak Former _____ Steak Cutter _____ 8210 Cryovac		
<u>64 MEAT GRINDING AREA</u> _____ General Housekeeping _____ Doors _____ Walls _____ Floor _____ Ceiling _____ Lights _____ Pipes _____ Refrigeration Units _____ Exhaust _____ Tables _____ Hand Sink _____ Meat Sink		

AREA	DEFICIENCY	ACTION TAKEN
<u>Hydroflaker</u> <u>Conveyor #1</u> <u>Grinder #1</u> <u>Conveyor #2</u> <u>Grinder #2</u> <u>Platform</u> <u>Formax</u> <u>Tubs</u> <u>Scoops</u> <u>Shovels</u>		
<u>67 MEAT COOLER</u> <u>General Housekeeping</u> <u>Walls</u> <u>Floor</u> <u>Ceiling</u> <u>Doors</u> <u>Lights</u> <u>Pipes</u> <u>Refrigeration Units</u> <u>Table</u> <u>Carts</u>		
<u>PASSAGE 4</u> <u>General Housekeeping</u> <u>Walls</u> <u>Floor</u> <u>Lockers</u> <u>Desk</u>		

PRODUCT EVALUATION

Date _____

Product _____

Brand _____

Unit Size _____

Requested by _____

Test against Specifications _____

To Be Used for Restaurant/Commissary _____

Date Received in Laboratory _____

Laboratory Analysis

Test Kitchen Results

Comments

White/Lab
Yellow/Test KitchenPink/Purchasing
Gold/Commissary Manager

APPENDIX B

DESCRIPTIONS OF THE MEAT ROOM EQUIPMENT SENSITIVE LOCATIONS MONITORED DURING THE PRE-OPERATION INSPECTION

1. HYDRAUFLAKER TABLE - That part of the Hydrauflaker where the 60-pound boxes of frozen meat are placed and pushed into the Hydrauflaker blades.
2. HYDRAUFLAKER BLADE - One of 16 "randomly" chosen blades used to flake/slice the frozen meat.
3. CONVEYOR #1 BELT - The conveyor belt on the conveyor linking the Hydrauflaker and the hopper for Grinder #1.
4. CONVEYOR #1 SIDE - The inside side portion of Conveyor #1.
5. CONVEYOR #2 BELT - The conveyor belt on the conveyor linking the Grinder #2 to the Formax Hopper.
6. CONVEYOR #1 TOP - The top of Conveyor #1 where the meat falls into the hopper for Grinder #1.
7. HOPPER #1 - The inside of the hopper for Grinder #1.
8. GRINDER #1 THROAT - The inside of the grinding mechanism for Grinder #1.
9. GRINDER AUGER - The auger of either Grinder #1 or Grinder #2. When swabbed, the Grinders have been disassembled and are stored on the drainage cart. Both augers are the same.
10. GRINDER BLADE - The blade from either Grinder #1 or Grinder #2.
11. HOPPER #2 - The cover on the top of the hopper of Grinder #2.
12. GRINDER #2 THROAT - The inside of the grinding mechanism for Grinder #2.
13. FORMAX HOPPER - The patty machine hopper that receives ground product from Conveyor #2.
14. FORMAX PLATES - That part of the patty machine containing the four dies. These die holes are circular.
15. FORMAX AUGER - One of four augers located at the bottom of the Formax Hopper. All four are alike and, when swabbed, the patty machine is disassembled.
16. FORMAX CONVEYOR BELT - That part of the patty machine which transports the finished patties out of the machine.

17. FORMAX PLUNGER - The plunger mechanism of the patty machine which pushes the formed patty out of the die hold in the Formax Plate.
18. PAPER CHUTE - That part of the patty machine where the paper is stored prior to being delivered to the finished patty.
19. SHOVEL - The stainless steel shovel used to load Conveyor #1 with ground fat and/or ground beef.
20. WHITE TUB - A container on wheels used to transport 60-pound cases of fresh or frozen meat, fat, or ground meat.
21. STAINLESS STEEL TUB - A container used for the same purposes as the White Tub.
22. BARREL - The waste storage container in the meat room.
23. SCOOP - A stainless steel scoop used to bag bulk ground beef into six-pound bags.
24. CUTTING KNIVES - The utensils used to process beef loins into steaks.

APPENDIX C

PERCENT FAT IN THE PRETEST VS. PERCENT
FAT IN THE FINISHED PATTY

DATE, 1980	AVERAGE PRETEST ¹ FAT CONTENT, %	AVERAGE FINISHED PATTY ² FAT CONTENT (POST TEST), %
May 5	15.8	21.9
May 9	17.5	22.8
May 10	21.0	22.5
May 13	24.5	22.0
May 15	21.5	23.6
May 16	25.5	24.4
May 17	27.5	24.8
May 21	23.5	22.4
May 22	23.3	22.8
May 27	20.8	23.5
May 29	18.0	22.1
May 30	21.5	23.5
May 31	20.0	22.8
June 3	23.3	23.6
June 4	17.8	23.3
June 5	10.4	21.4
June 6	14.3	19.0
June 10	15.3	21.8
June 12	10.5	19.8
June 13	24.3	24.3
June 14	15.5	23.8
June 17	14.3	22.5
June 19	16.8	23.3
June 21	19.0	23.3
June 24	20.0	23.3
June 26	16.5	20.5
June 27	18.5	21.2
June 28	15.0	21.6
July 1	21.4	23.3
July 2	17.5	21.1
July 3	21.0	21.6
July 5	22.0	23.3
July 8	20.2	21.5
July 10	21.5	22.8

¹Pretest fat content was obtained by grinding a batch of the boneless beef and beef plates, analyzing two nine-gram samples, and averaging the results.

²Post test fat content was obtained by averaging the post values for each date.

SUMMARY TABLE OF PRETEST VS. POST TEST

TEST	AVERAGE FAT CONTENT, %	STANDARD DEVIATION	RANGE
Pretest	19.3	4.0	10.4 to 27.5
Post test	22.5	1.3	19.0 to 24.8

DATE, 1980	AVERAGE PRETEST ¹ FAT CONTENT, %	AVERAGE FINISHED ² PATTY WEIGHT, GRAMS
February 1	21.0	43.68
February 5	23.4	43.94
February 7	21.8	44.70
February 8	22.9	44.63
February 12	22.1	44.61
February 14	22.9	44.57
February 15	22.9	44.43
February 16	23.4	45.40
February 19	24.1	44.98
February 21	21.6	44.24
February 26	20.3	45.01
February 28	19.7	44.97
March 6	19.5	44.83
March 7	21.7	45.38
March 8	21.2	45.57
March 11	25.0	44.83
March 13	22.0	45.46
March 14	22.1	44.70
March 18	23.5	45.55
March 20	22.0	45.09
March 21	22.0	45.41
March 25	22.7	44.78
March 27	23.2	45.05
April 3	21.4	44.76
April 5	23.8	44.65
April 17	20.1	43.89
April 18	20.0	45.06
May 9	17.5	44.31
May 10	21.0	44.70
May 13	24.5	44.26
May 15	21.5	44.36
May 16	25.5	44.40
May 17	27.5	44.25
May 21	23.5	44.05
May 22	23.3	44.61
May 27	20.8	44.80
May 29	18.0	44.49
May 30	21.5	44.32
May 31	20.0	44.20
June 3	23.3	44.50

APPENDIX D

PERCENT FAT IN THE PRETEST VS. PATTY WEIGHT

DATE, 1980	AVERAGE PRETEST ¹ FAT CONTENT, %	AVERAGE FINISHED ² PATTY WEIGHT, GRAMS
June 4	17.8	44.13
June 5	10.4	44.51
June 6	14.3	44.57
June 10	15.3	43.84
June 12	10.5	44.46
June 13	24.3	44.45
June 17	14.3	44.11
June 19	16.8	44.84
June 20	20.0	44.21
June 24	20.0	43.75
June 26	16.5	44.28
June 27	18.5	44.53
June 28	15.0	43.93
July 1	21.4	44.67
July 2	17.5	44.83
July 3	21.0	44.85
July 8	20.2	44.70
July 10	21.5	44.89
July 12	22.8	44.77
July 17	25.0	45.35
July 18	24.0	44.72
July 19	23.0	44.93
July 22	23.4	44.62
July 24	22.8	44.78
July 25	23.4	44.72
July 26	20.0	45.54
July 29	24.7	44.56
July 31	22.5	44.34
August 1	24.2	44.47
August 2	23.3	44.77
August 5	23.9	44.11
August 7	20.3	44.12
August 8	23.0	43.65
August 9	23.0	44.68
August 12	16.5	43.85
August 14	18.5	44.59
August 15	17.5	44.32
August 16	21.5	44.88
August 19	15.6	44.88
August 21	19.0	44.21

DATE, 1980	AVERAGE PRETEST ¹ FAT CONTENT, %	AVERAGE FINISHED ² PATTY WEIGHT, GRAMS
August 22	24.3	44.56
August 23	22.8	44.60
August 26	23.2	44.20
August 28	22.1	43.99
August 29	23.9	44.14
August 30	21.3	44.54
September 2	23.3	43.29
September 4	22.8	44.14
September 5	22.5	44.73
September 6	22.0	45.30
September 9	21.2	43.88
September 11	21.8	44.25
September 12	23.7	44.64
September 13	23.7	44.51
September 16	22.0	44.36
September 18	22.6	44.66
September 19	21.6	44.40
September 20	22.3	44.53
September 23	21.1	44.29
September 25	21.0	44.45
September 26	16.2	44.67
September 27	17.5	44.23
September 28	19.2	44.30
October 3	22.7	44.53
October 4	22.9	44.61
October 7	23.7	44.77
October 9	22.2	44.64
October 10	22.9	44.61
October 11	16.6	44.58
October 14	15.4	44.87
October 16	17.5	44.71
October 17	18.8	44.83
October 18	22.5	44.88

¹Pretest fat content was obtained by grinding a batch of the boneless beef and beef plates, analyzing two nine-gram samples, and averaging the results.

²Patty weight was obtained by averaging the patty weight values for each date.

SUMMARY TABLE OF PRETEST VS. PATTY WEIGHT

ITEM	PRETEST FAT CONTENT, %	PATTY WEIGHT, GRAMS
Average	21.1	44.56
Standard deviation	3.0	0.42
Range	10.4 to 25.5	43.29 to 45.57

APPENDIX E

DETECTION AND IDENTIFICATION OF SALMONELLA

APPENDIX E

DETECTION AND IDENTIFICATION OF SALMONELLA¹A. Isolation of Salmonella

1. Transfer 10 g. of sample into 90 ml. of selenite cystine broth. Tighten lid and gently shake mixture.
2. Incubate 24 + 2 hrs. at 35°C. (Note: products which do not receive pre-enrichment, such as nonpasteurized liquid and frozen eggs and highly contaminated meats, may be promptly streaked on selective culture media as described in the next step, item 3 below.)
3. Streak 3 mm. loopful of incubated selenite cystine broth on brilliant green agar (A12), Salmonella-Shigella agar (A70), and bismuth sulfite agar (A8).
4. Repeat with 3 mm. loopful of tetrathionate broth.
5. Incubate plates 24 + 2 hrs. at 35°C.
6. Note appearance of typical Salmonella colonies.
 - a. Brilliant green agar - colorless, pink to fuschia, translucent to opaque, with surrounding medium pink to red. Some Salmonellae appear as transparent green colonies if surrounded by organisms fermenting lactose or sucrose, since these carbohydrate-fermenting organisms produce colonies and zones that are yellow-green or green. Less than 1 percent of the Salmonellae are atypical in that they ferment lactose and appear as yellow-green or green colonies.
 - b. Salmonella-Shigella agar - uncolored to pale pink, opaque, transparent or translucent; some strains produce black-centered colonies.
 - c. Bismuth sulfite agar - brown, black, sometimes with metallic sheen. Surrounding medium is usually brown at first, turning black with increasing incubation time. Some strains produce green colonies with little or no darkening of surrounding medium.

¹FDA Bacteriological Analytical Manual, fourth edition, 1976.

DETECTION AND IDENTIFICATION OF SALMONELLAA. Isolation of Salmonella

1. Transfer 10 µl of sample into 30 ml of selective cysteine broth. Tighten lid and gently shake mixture.
2. Incubate 24 ± 2 hrs. at 35°C . Inoculate medium which do not receive pre-enrichment, such as selenite F, tetrathionate and selenite S, and selenite F, may be promptly streaked on selenite F culture media as described in the next step (see 3 below).
3. Streak 3 mm. loopful of incubated selenite F broth on brilliant green agar (BG), Salmonella-Shigella agar (AS), and selenite F agar (SF).
4. Repeat with 3 mm. loopful of tetrathionate broth.
5. Incubate plates 24 ± 2 hrs. at 35°C .
6. Note appearance of typical Salmonella colonies.
 - a. Brilliant green agar - colorless, pink to translucent to opaque, with surrounding medium pink to red. Some Salmonella appear as transparent green colonies if surrounded by organisms fermenting lactose or sucrose, since these carbonhydrate-fermenting organisms produce colorless and zones that are yellow-green or green. Less than 1 percent of the Salmonella are atypical in that they ferment lactose and appear as yellow-green or green colonies.
 - b. Salmonella-Shigella agar - uncolored to pale pink, opaque, transparent or translucent; some strains produce black-centered colonies.
 - c. Selenite F agar - brown, black, sometimes with metallic sheen. Surrounding medium is usually brown at first, turning black with increasing incubation time. Some strains produce green colonies with little or no darkening of surrounding medium.

7. Select two or more typical or suspicious colonies, if present, on brilliant green, Salmonella-Shigella or bismuth sulfite agar plates for inoculation to triple sugar iron (TSI) agar and lysine iron agar (LIA). If plates do not have typical or suspicious colonies or do not contain growth, incubate additional 24 hrs.
8. Inoculate TSI agar (A81) and LIA agar (A44) slants with portion of each colony by streaking slant and stabbing butt of each agar. After inoculating TSI agar with needle, do not obtain more inoculum from colony and do not heat needle until inoculation of LIA agar is completed.
9. Retain plates after picking selected colonies and store at 5-8°C or 25°C.
10. Incubate TSI agar slants 24 + 2 hrs. at 35°C.* Salmonella-positive cultures have alkaline (red) slants and acid (yellow) butts, with or without H₂S (blackening of agar). Do not exclude H₂S negative TSI agar slants.
11. Incubate LIA agar slants 24 + 2 hrs. at 35°C.* Salmonella positive cultures have an alkaline (purple) reaction throughout the medium. If H₂S is produced, butt of medium is blackened.
12. If typical reactions are not observed, pick additional colonies from brilliant green, Salmonella-Shigella and bismuth sulfite plates to TSI and LIA slants.
13. All presumptive-positive Salmonella cultures on TSI agar and LIA media (as described in steps 10 and 11 of this section) are retained for biochemical characterization. TSI cultures which appear to be non-Salmonellae (including yellow slants) cannot be excluded if they give typical Salmonella reactions in LIA. These cultures should be treated as presumptive positive TSI agar cultures and subjected to further biochemical testing. LIA is useful in the detection of atypical Salmonella which ferments lactose or sucrose and the lactose-fermenting Arizona.
14. Apply biochemical and serological identification tests to a) three presumptive positive TSI agar cultures recovered from selenite cystine, and b) three presumptive positive TSI agar cultures from

*Cap tubes loosely to maintain aerobic conditions while incubating slants to prevent excessive H₂S production.

tetrathionate broth, if present. c) A minimum of six TSI cultures should be examined. d) If necessary, all six presumptive positive cultures may be selected from one set of selective agar plates.

B. Identification of Salmonella

1. Mixed cultures

- a. If any TSI agar slant culture appears to be mixed, streak on MacConkey's agar (A45) or brilliant green agar.
- b. Incubate plates for 24 ± 2 hrs. at 35°C . Observe results as follows:
 - 1) MacConkey's agar - typical colonies appear transparent and colorless, sometimes with dark center.
 - 2) Brilliant green agar - see item A, 6 above.
- c. Pick, with needle, at least two colonies onto separate TSI slants, by streaking each slant and stabbing butts.

2. Pure cultures

a. Urease test:

- 1) Transfer two loopfuls (approximately 3 mm. each) of growth from each presumptive positive TSI agar slant culture to urea broth (A89) tubes. Incubate broth tubes for 24 ± 2 hrs. at 35°C ; or
- 2) Inoculate rapid urea broth (A90) tubes and incubate for 2 hrs. in water bath at $37 \pm 0.5^{\circ}\text{C}$.
- 3) Discard all cultures that give positive test (purple-red color).
- 4) Retain, for further study, all cultures that give a negative test (no change in orange color or medium).

3. Testing urease-negative cultures

- a. Lysine iron agar (LIA) (or see B, 4, b, below).
 - 1) Make TSI agar culture with needle, streak slant, and stab butt.

- 2) Replace cap loosely, and incubate 48 ± 2 hrs. at 35°C .
 - 3) Examine at least every 24 hrs.
 - 4) Salmonella causes an alkaline reaction of purple color throughout medium. Negative test is purple slant or red slant and yellow butt.
- b. Lysine decarboxylase broth (A43).
- 1) Inoculate broth with loopful of TSI agar culture.
 - 2) Replace cap tightly, and incubate 48 ± 2 hrs. at 35°C .
 - 3) Examine at least every 24 hrs.
 - 4) Salmonella causes alkaline reaction producing purple color throughout the broth. Negative test is permanent yellow color throughout the broth.
- c. Phenol red dulcitol broth (A61) (or see B, 4, d, below).
- 1) Inoculate broth with loopful (approximately 3 mm.) from TSI agar culture.
 - 2) Incubate 48 ± 2 hrs. at 35°C .
 - 3) Examine at least every 24 hrs.
 - a) Most Salmonellae give positive test: gas formation and acid reaction (yellow).
 - b) Negative test is alkaline red and no gas.
- d. Purple broth base (A66) with dulcitol may be substituted for phenol red dulcitol broth (see B, 4, c, 1) - 3) above).
- e. Tryptophane broth (A86)
- 1) Inoculate broth with loopful (approximately 3 mm.) of TSI agar culture.
 - 2) Incubate 24 ± 2 hrs. at 35°C , and test as follows:
 - a) KCN broth (A64).

- (1) Transfer loopful (approximately 3 mm.) of tryptophane broth to KCN broth.
 - (2) Heat rim of tube to form a good seal when stoppered with a wax-coated cork, and incubate 48 ± 2 hrs. at 35°C .
 - (3) Salmonella do not grow in this broth; negative test is shown by lack of turbidity.
- b) Malonate broth (A47)
- (1) Transfer loopful (approximately 3 mm.) of tryptophane broth to malonate broth.
 - (2) Incubate 48 ± 2 hrs. at 35°C .
 - (a) Negative test results with Salmonella are shown by green color (unchanged).
 - (b) Positive test is shown by blue color.
- c) Indole test (B13)
- (1) Transfer 5 ml. of tryptophane broth (A86) culture to empty test tube.
 - (2) Add 0.2 - 0.3 ml. of Kovac's reagent.
 - (3) Positive test is shown by deep red color.
- f. Salmonella serological flagellar (H) test. See this chapter, Part B, 3, a-c.
- g. Salmonella serological somatic (O) plate test. See this chapter, Part C, 1, a-h.
- h. For classification of Salmonella, see Table VI-1, columns A and B, 1-8.
4. Additional biochemical tests. (Note: Perform additional tests on cultures that do not classify as Salmonella sp. (See Part B, 4, h, above.)
- a. Phenol red lactose broth (A61) or purple lactose broth (A66).
- 1) Inoculate with loopful (approximately 3 mm.) of growth from each unclassified TSI agar slant.

- 2) Incubate 48 ± 2 hrs. at 35°C .
 - 3) Examine at least every 24 hrs.
 - a) Positive test is shown by gas formation and/or acid reaction (yellow).
 - b) Negative test is shown by alkaline reaction and no gas.
 - 4) A negative test usually results with Salmonella.
- b. Phenol red sucrose broth (A61) or purple sucrose broth (A66) -- same as shown in Part B, 5, a, 1) - 4), above.
- c. MR-VP medium (A26).
- 1) Inoculate with loopful (approximately 3 mm.) of growth from each unclassified TSI agar slant.
 - 2) Incubate 48 ± 2 hrs. at 35°C .
 - 3) Perform VP test (B36).
 - a) Transfer 1 ml. of 48 hr. culture to test tube.
 - b) Add 0.6 ml. of α -naphthol, and shake.
 - c) Add 0.2 ml. of 40 percent NaOH solution, and shake.
 - d) Optionally, add a few crystals of creatine.
 - e) Read results after 4 hrs.
 - (1) Positive VP test is development of eosine pink color.
 - (2) A negative test results with Salmonella.
 - f) Reincubate remainder of MR-VP medium an additional 48 hrs. at 35°C .
 - 4) Perform MR test (B18).
 - a) Transfer 5 ml. of culture from 3), f), above, to test tube after final incubation.

- b) Add five-six drops of methyl red solution.
- c) Read results immediately. Salmonella positive is red; yellow is negative.
- d. Simmons citrate agar (A73)
 - 1) Inoculate with needle from growth of unclassified TSI slant.
 - 2) Inoculate by streaking slant and stabbing butt.
 - 3) Incubate 96 ± 2 hrs. at 35°C .
 - a) A positive test is indicated by growth, usually accompanied by a color change from green to blue.
 - b) Negative test is indicated by no growth and no color change.
 - 4) Salmonella usually causes positive test.
(Note: for classification of Salmonella, see Table VI-1, columns A and B).
- 5. Results indicating absence of Salmonella--discard TSI agar cultures yielding any one of the following results:
 - a. Positive indole and negative serological flagellar (H) test.
 - b. Positive KCN broth and negative lysine decarboxylase test.
 - c. Positive KCN broth test, positive VP test and negative methyl red test.
- C. Salmonella serological tests (all Salmonella antisera should be pretested with known cultures).
 - 1. Polyvalent somatic (O) plate test.
 - a. Using wax pencil, mark off two sections about 1×2 cm. each on inside of glass or plastic petri dish or glass slide.
 - b. Place $1/2$ of a 3 mm. loopful of culture from 24-48 hr. test TSI agar slant on dish in upper part of each marked section.

- c. Add one drop of saline solution (B27) to lower part of each section.
 - d. Emulsify culture in saline solution with clean, sterile transfer loop or needle in both sections.
 - e. Add one drop of Salmonella polyvalent somatic (0) antiserum to one section.
 - f. Mix antiserum and culture with clean, sterile transfer loop or needle.
 - g. Tilt mixtures back and forth for one min. and observe against dark background in good illumination. Any degree of agglutination is a positive reaction.
 - h. Classify polyvalent somatic (0) test.
 - 1) Positive - agglutination in test mixture; no agglutination in saline control.
 - 2) Negative - no agglutination in test mixture; no agglutination in saline control.
 - 3) Non-specific - agglutination in both test and control.
2. If positive, send to Public Health Lab for serotyping.

APPENDIX F

PROCESS CAPABILITY ANALYSIS AND ANALYSIS OF COVARIANCE DATA

NET PATTY WEIGHTS, GRAMS

DATE: August 26, 1980TIME: 8:45 AMBATCH: Number 1PSI: 150

POSITION NUMBER

1	2	3	4	Σx	$\bar{x}$	R
44.60	44.03	43.31	44.11	176.05	44.01	1.29
44.44	44.06	43.32	43.75	175.57	43.89	1.12
44.29	44.06	43.71	43.88	175.94	43.99	0.58
44.10	43.85	43.62	43.77	175.34	43.84	0.48
44.34	43.88	43.76	43.91	175.89	43.97	0.58
44.35	43.96	43.52	43.66	175.49	43.87	0.83
44.24	43.97	43.65	44.09	175.95	43.99	0.59
44.83	43.89	43.50	43.78	176.00	44.00	1.33
44.32	44.04	43.41	43.79	175.56	43.89	0.91
44.32	44.05	43.46	43.97	175.80	43.95	0.86

DATE: August 26, 1980TIME: 9:10 AMBATCH: Number 2PSI: 150

POSITION NUMBER

1	2	3	4	Σx	$\bar{x}$	R
44.34	44.18	44.26	44.20	176.98	44.25	0.16
44.34	44.03	43.81	43.92	176.10	44.03	0.22
44.35	44.01	43.87	44.10	176.33	44.08	0.48
44.59	44.27	43.80	44.10	176.76	44.19	0.79
44.33	44.03	43.82	44.29	176.47	44.12	0.51
44.35	43.97	43.79	44.01	176.12	44.03	0.56
44.80	44.08	43.72	44.04	176.64	44.16	1.08
44.32	44.04	43.65	43.90	175.91	43.98	0.67
44.24	44.05	43.66	43.90	175.85	43.96	0.58
44.26	43.87	43.66	43.91	175.70	43.93	0.60

DATE: August 26, 1980TIME: 9:45 AMBATCH: Number 3PSI: 150

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
44.84	44.47	44.31	44.67	178.29	44.57	0.53
44.88	44.16	44.21	44.64	177.89	44.47	0.72
44.82	44.29	44.06	44.57	177.74	44.44	0.76
44.86	44.59	44.01	44.49	177.95	44.49	0.85
44.81	44.65	44.08	44.87	178.41	44.60	0.79
44.88	44.05	44.01	44.41	177.35	44.34	0.87
44.75	44.44	44.32	44.47	177.98	44.50	0.43
44.81	44.19	44.21	44.69	177.90	44.48	0.62
44.47	44.36	44.32	44.40	177.55	44.39	0.15
44.67	44.20	44.07	44.29	177.23	44.31	0.60

DATE: August 26, 1980TIME: 12:00 NoonBATCH: Number 4PSI: 140

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
44.40	44.24	44.03	44.80	177.47	44.37	0.77
44.17	44.11	44.26	44.90	177.44	44.36	0.79
44.22	44.23	44.47	44.75	177.67	44.42	0.53
44.22	44.17	44.14	44.84	177.37	44.34	0.70
44.21	44.31	44.25	44.73	177.50	44.38	0.52
44.36	44.27	44.29	44.56	177.48	44.37	0.29
44.23	44.07	44.22	44.45	176.97	44.24	0.38
43.98	44.31	44.26	44.61	177.16	44.29	0.63
44.15	44.20	44.39	44.71	177.45	44.36	0.56
44.13	44.19	44.21	44.82	177.35	44.34	0.69

DATE: August 26, 1980TIME: 12:15 PMBATCH: Number 5PSI: 140

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
44.41	43.84	44.53	44.83	177.61	44.40	0.43
44.22	43.88	44.29	44.73	177.12	44.28	0.66
44.20	44.10	44.27	44.60	177.17	44.29	0.50
44.10	43.86	44.31	44.59	176.86	44.22	0.76
44.20	44.04	44.37	44.59	177.18	44.30	0.55
44.22	43.94	44.09	44.81	177.06	44.27	0.87
44.66	44.03	44.15	44.72	177.56	44.39	0.69
44.12	43.90	44.10	44.77	176.89	44.22	0.87
44.24	44.01	44.09	44.69	177.03	44.26	0.68
44.25	43.97	44.24	44.51	177.03	44.26	0.60

DATE: September 4, 1980TIME: 9:15 AMBATCH: Number 1PSI: 125

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
43.45	43.27	41.91	44.30	172.93	43.23	2.39
43.19	44.92	44.08	43.80	175.99	44.00	1.73
43.19	43.56	44.00	43.38	174.33	43.58	1.01
44.77	43.44	43.77	43.23	175.21	43.80	1.54
44.13	42.94	43.86	43.01	173.94	43.49	1.19
42.85	43.20	44.27	43.27	173.59	43.40	1.42
43.42	42.94	43.83	43.61	173.80	43.45	0.89
43.51	43.55	44.00	43.26	174.32	43.58	0.74
42.70	43.37	43.16	44.33	173.56	43.39	1.63
44.47	42.96	43.49	42.91	173.83	43.46	1.56

DATE: September 23, 1980TIME: 9:00 AMBATCH: Number 1PSI: 140

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
44.12	43.54	43.56	44.18	175.40	43.85	0.64
43.97	44.67	43.84	44.27	176.75	44.19	0.83
44.11	43.74	43.75	43.56	175.16	43.79	0.55
43.88	43.54	43.72	44.45	175.59	43.90	0.91
44.27	43.35	43.85	44.24	175.71	43.93	0.92
44.10	43.80	43.68	44.13	175.71	43.93	0.45
43.99	43.76	43.44	44.05	175.24	43.81	0.61
43.75	43.69	44.01	43.90	175.35	43.84	0.32
44.02	43.87	43.74	44.27	175.90	43.98	0.53
44.78	43.78	43.55	44.31	176.42	44.11	1.23

DATE: September 29, 1980TIME: 8:00 AMBATCH: Number 1PSI: 140

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
43.21	43.27	43.41	44.35	174.24	43.56	1.14
43.06	43.08	43.15	43.98	173.27	43.32	0.92
42.98	43.24	43.26	44.01	173.49	43.37	1.03
43.02	43.18	44.75	43.96	174.91	43.73	1.73
42.72	43.27	43.34	44.01	173.34	43.34	1.29
43.05	43.42	43.27	43.95	173.69	43.42	0.90
43.02	43.58	42.99	44.13	173.72	43.43	1.14
43.08	42.72	43.47	44.06	173.33	43.33	1.34
42.87	42.93	43.19	44.09	173.08	43.27	1.22
43.29	43.15	43.06	43.85	173.35	43.34	0.79

DATE: September 29, 1980TIME: 8:50 AMBATCH: Number 2PSI: 140

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
43.84	44.18	43.89	44.46	176.37	44.09	0.62
43.67	44.27	43.61	43.87	175.42	43.86	0.66
43.49	44.27	43.51	43.78	175.05	43.76	0.78
43.61	44.21	43.58	43.86	175.26	43.82	0.63
43.63	44.12	43.76	43.87	175.38	43.85	0.49
43.69	44.08	43.79	43.96	175.52	43.88	0.39
43.75	44.08	43.92	43.88	175.63	43.91	0.33
44.02	43.98	43.57	43.74	175.31	43.83	0.45
43.63	44.00	43.64	43.86	175.13	43.78	0.37
43.63	43.82	43.77	43.99	175.21	43.80	0.36

DATE: September 29, 1980TIME: 9:30 AMBATCH: Number 3PSI: 140

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
43.65	43.90	43.67	44.23	175.45	43.86	0.58
43.77	43.96	43.78	44.20	175.71	43.93	0.43
43.87	44.04	43.71	44.30	175.92	43.98	0.59
43.76	43.95	43.97	44.36	176.04	44.01	0.60
43.89	44.19	43.83	44.18	176.09	44.02	0.36
43.86	44.44	43.95	44.21	176.46	44.12	0.58
44.14	44.14	44.23	44.04	176.55	44.14	0.19
44.02	43.84	43.93	44.23	176.02	44.01	0.39
43.96	43.87	43.74	44.22	175.79	43.95	0.48
43.95	43.79	43.80	44.16	175.70	43.93	0.37

DATE: September 29, 1980TIME: 10:10 AMBATCH: Number 4PSI: 140

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
44.36	44.83	44.87	44.16	178.22	44.56	0.71
44.24	44.97	44.47	44.11	177.79	44.45	0.86
44.36	44.92	44.63	44.08	177.99	44.50	0.84
44.32	44.83	44.75	44.42	178.32	44.58	0.51
44.16	44.77	44.48	44.58	177.99	44.50	0.61
44.01	44.64	44.35	44.41	177.41	44.35	0.63
43.96	44.73	45.06	44.31	178.06	44.52	1.10
44.07	44.61	44.18	44.16	177.02	44.26	0.54
44.14	44.87	44.34	44.56	177.91	44.48	0.73
44.18	44.90	44.34	44.26	177.68	44.42	0.72

DATE: October 7, 1980TIME: 9:15 AMBATCH: Number 1PSI: 130SAMPLE: Number 1

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
44.80	45.03	45.01	44.64	179.48	44.87	0.67
44.75	45.01	45.02	44.63	179.40	44.85	0.65
44.74	44.87	45.12	44.77	179.51	44.88	0.38
44.87	44.97	44.88	44.70	179.42	44.86	0.27
44.66	44.88	45.08	44.60	179.22	44.81	0.48
44.75	44.60	44.99	44.62	178.96	44.74	0.39
44.45	44.73	44.95	44.60	178.73	44.68	0.50
44.54	44.57	44.89	44.31	178.31	44.58	0.58
44.58	44.68	44.77	44.33	178.36	44.59	0.44
44.57	44.94	44.58	44.43	178.52	44.63	0.51

DATE: October 7, 1980TIME: 9:20 AMBATCH: Number 1PSI: 130SAMPLE: Number 2

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
44.50	45.05	44.96	45.05	179.56	44.89	0.55
44.89	44.91	44.78	45.15	179.73	44.93	0.37
45.29	44.90	45.00	45.00	180.19	45.05	0.39
45.14	44.99	45.10	45.35	180.58	45.15	0.36
44.91	45.04	45.10	44.97	180.02	45.01	0.19
45.08	44.97	44.89	45.03	179.97	44.99	0.19
44.86	45.87	44.93	45.16	180.82	45.21	1.01
45.00	44.83	45.04	44.86	179.73	44.93	0.21
44.95	44.95	45.03	44.97	179.90	44.98	0.08
44.83	44.94	44.82	44.94	179.53	44.88	0.12

DATE: October 7, 1980TIME: 9:27 AMBATCH: Number 1PSI: 130SAMPLE: Number 3

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
44.93	45.98	44.94	44.89	180.74	45.19	1.09
44.83	45.01	45.01	44.70	179.55	44.89	0.31
44.83	44.98	44.82	44.86	179.49	44.87	0.16
44.88	44.96	44.84	44.95	179.63	44.91	0.12
44.89	44.98	44.89	44.89	179.65	44.91	0.09
45.03	44.82	44.72	44.88	179.45	44.86	0.31
44.89	44.96	44.69	44.81	179.35	44.84	0.27
45.21	44.96	45.00	44.86	180.03	45.01	0.35
45.06	45.03	44.89	44.84	179.82	44.96	0.22
45.29	44.89	45.42	44.93	180.53	45.13	0.53

DATE: October 7, 1980TIME: 9:35 AMBATCH: Number 1PSI: 130SAMPLE: Number 4

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
45.06	46.22	45.17	45.97	182.42	45.61	1.16
45.07	44.85	45.06	45.12	180.10	45.03	0.27
46.01	44.99	45.13	45.22	181.35	45.34	1.02
44.91	44.37	45.27	44.78	179.33	44.83	0.90
44.96	44.97	44.99	45.07	179.99	45.00	0.11
45.05	45.19	45.29	45.07	180.60	45.15	0.24
44.89	44.96	45.02	44.94	179.81	44.95	0.13
45.13	44.92	45.06	44.97	180.08	45.02	0.21
44.86	45.35	45.17	44.97	180.35	45.09	0.49
45.08	45.05	45.07	45.15	180.35	45.09	0.10

DATE: October 21, 1980TIME: 8:07 AMBATCH: Number 1PSI: 140SAMPLE: Number 1

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
44.41	44.66	44.90	44.58	178.55	44.64	0.49
44.47	44.98	44.53	44.70	178.68	44.67	0.52
44.46	44.56	44.65	44.48	178.15	44.54	0.19
44.52	44.53	44.74	44.48	178.27	44.57	0.26
44.44	44.76	44.60	44.57	178.37	44.59	0.32
44.41	44.60	44.64	44.17	177.82	44.46	0.47
44.51	44.55	44.33	44.46	177.85	44.46	0.22
44.45	44.44	44.81	44.36	178.06	44.52	0.45
44.49	44.64	44.56	44.48	178.17	44.54	0.16
44.38	44.49	44.51	44.19	177.57	44.39	0.32

DATE: October 21, 1980TIME: 8:11 AMBATCH: Number 1PSI: 140SAMPLE: Number 2

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
44.62	44.69	44.66	44.07	178.04	44.51	0.62
44.30	44.56	44.60	44.30	177.76	44.44	0.30
44.37	44.74	44.87	44.30	178.28	44.57	0.57
44.38	44.72	44.74	44.26	178.10	44.53	0.48
44.42	44.72	45.34	44.46	178.94	44.74	0.92
44.49	45.00	44.75	44.43	178.67	44.67	0.57
44.45	44.60	44.69	44.69	178.43	44.61	0.24
44.36	44.67	44.58	44.61	178.22	44.56	0.31
44.55	44.50	45.04	44.55	178.64	44.66	0.54
44.60	45.04	44.65	44.67	178.96	44.74	0.44

DATE: October 21, 1980TIME: 8:16 AMBATCH: Number 1PSI: 140SAMPLE: Number 3

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
44.57	44.82	44.74	44.51	178.64	44.66	0.31
44.52	45.47	44.84	44.39	179.22	44.81	1.08
44.40	44.56	44.39	44.33	177.68	44.42	0.23
44.47	44.82	44.55	44.27	178.11	44.53	0.55
44.52	44.53	44.68	44.27	178.00	44.50	0.41
44.61	44.86	44.62	44.35	178.44	44.61	0.51
44.20	44.28	44.47	44.27	177.22	44.31	0.27
44.43	44.49	44.64	44.38	177.94	44.49	0.26
44.39	44.71	44.63	44.42	178.15	44.54	0.32
44.47	44.70	44.78	44.19	178.14	44.54	0.59

DATE: October 21, 1980TIME: 8:22 AMBATCH: Number 1PSI: 140SAMPLE: Number 4

POSITION NUMBER						
1	2	3	4	Σx	$\bar{x}$	R
44.83	44.89	45.57	44.64	179.93	44.98	0.93
44.70	44.98	44.87	44.80	179.35	44.84	0.28
44.80	45.01	44.98	44.42	179.21	44.80	0.59
44.91	44.72	45.14	44.87	179.64	44.91	0.42
45.00	44.95	44.82	44.73	179.50	44.88	0.27
44.95	44.34	44.92	44.78	178.99	44.75	0.61
44.82	44.60	44.92	44.56	178.90	44.73	0.36
44.78	44.84	44.83	44.77	179.22	44.81	0.06
44.54	45.01	45.05	44.88	179.48	44.87	0.51
44.79	44.80	44.91	44.75	179.25	44.81	0.16

SUMMARY TABLE OF NET PATTY WEIGHTS DATA

DATE, 1980	BATCH NUMBER	SAMPLE NUMBER	$\Sigma \bar{x}$	$\bar{\bar{x}}$	ΣR	$\bar{R}$
August 26	1	-	439.40	43.94	8.57	0.86
August 26	2	-	440.73	44.07	5.65	0.57
August 26	3	-	444.59	44.46	6.32	0.63
August 26	4	-	443.47	44.35	5.86	0.59
August 26	5	-	442.89	44.29	6.61	0.66
September 4	1	-	435.38	43.54	14.10	1.41
September 23	1	-	439.33	43.93	6.99	0.70
September 29	1	-	434.11	43.41	11.50	1.15
September 29	2	-	438.58	43.86	5.08	0.51
September 29	3	-	439.95	44.00	4.57	0.46
September 29	4	-	444.62	44.46	7.25	0.73
October 7	1	1	447.49	44.75	4.87	0.49
October 7	1	2	450.02	45.00	3.47	0.35
October 7	1	3	449.57	44.96	3.45	0.35
October 7	1	4	451.11	45.11	4.63	0.46
October 21	1	1	445.38	44.54	3.40	0.34
October 21	1	2	446.03	44.60	4.99	0.50
October 21	1	3	445.41	44.54	4.53	0.45
October 21	1	4	448.38	44.84	4.19	0.42

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