TIME/TEMPERATURE RELATIONSHIP OF PACKAGED MEALS DURING FREEZING: ELDERLY FEEDING PROGRAMS

by

CHERYL K. THOLE

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Approved by:

Mary B Gregoire

Major Professor

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INTRODUCTION

The 1980 census indicated approximately 412,000 Kansans were aged 60 or older (1). Of these, 37.8 percent lived in communities of 2,500 or less or in rural areas. An increase by as much as two percent in the rural elderly population is expected by 1990 in all but 16 of the 105 Kansas counties.

Delivery of meals to home bound elderly began as a private venture in 1954 in the United States to help provide adequate nutrition for recipients (2). Subsequently, the 1978 amendment of the Older Americans Act authorized government funding for home delivered nutrition services,which included meals and nutrition education (3).

Gatherer (4) and Cairns and Caggiula (5) conducted research to determine acceptability of hot home delivered meals. Major problems identified in their studies included: time between cooking and consumption, temperature control during delay periods, and inevitable loss of palatability, acceptability, and nutritional value.

Attempts to provide the elderly with frozen home delivered meals have met with mixed results. Lyons (6) reported that some elderly recipients of home delivered frozen meals resented the effort and energy expenditure needed to heat frozen meals. Osteraas, et al. (7) reported elderly ratings for frozen meals as equal to or superior to hot meals for taste, texture, appearance, convenience, and healthfulness. Yarrow (8) noted a cost savings with delivery of meals prepared and frozen at congregate sites.

Lauman (9) indicated one concern when preparing frozen meals for the elderly is that the elderly are more susceptible to disease organisms. Food must be handled with strict sanitary controls throughout the preparation and subsequent freezing processes to ensure that a microbiologically safe food product is prepared.

Several congregate meal site managers in Kansas frequently package and freeze food which was prepared for on-site meals but was not served. These frozen meals then are delivered to home bound elderly (10). Research has not been conducted to determine the amount of time that food, being frozen at the congregate sites, remains in the temperature danger zone.

Objectives

The purpose of this study is to determine time/temperature relationships in freezing individually packaged meals used in home bound elderly feeding programs. Specific objectives are to:

- investigate impact on freezing time of meal arrangement in the freezer
- examine if freezing time is related to freezing equipment

Definitions

For the purpose of this research, the following definitions will be used:

Congregate site - location of a government sponsored elderly feeding program providing meals and social interaction

Home delivery - a government sponsored feeding program using volunteers to deliver meals to the home bound elderly

REVIEW OF LITERATURE

History of Home Delivered Meals

The formal concept of home-delivered meals began when the Invalid Kitchens of London began sending hot meals to housebound patients in 1905 (11). During World War II, the Women's Voluntary Service of England began a country-wide movement of sending hot meals to homes of invalids who could not care for themselves. This program became known as "Meals on Wheels." The practice of delivering meals to homes of invalids spread over England and to other western countries. Meals on Wheels became a joint effort of volunteers and local authorities in Great Britain and New Zealand, with the trend of local authorities increasing their financial responsibility to the program (12).

The first United States Meals on Wheels program began in Philadelphia in 1954. The program was operated through a settlement house called the Lighthouse, and served 50 homebound clients a day (12). Prior to this time, it was the role of the good neighbor to bring food to the home during times when serious illness or chronic disease resulted in physical disability (13). Home delivered meal programs often were used to provide service to temporarily ill participants (14).

Pelcovits (14) indicated that initial government support for home delivered meals began in 1968 when $2 million in federal funding was provided to the Title IV special program to improve elderly nutrition services. The program's purpose was to support research projects testing techniques and delivery systems, thus improving participants'

diets and enhancing their feelings of self-esteem and self-reliance which were related to good nutrition. Posner (15) reported that in 1980 there were 12,000 congregate nutrition programs in the United States providing home-delivered meals to elderly, and 1,100 privately-funded meals-on-wheels programs.

Salkin (16) reported that in 1988, Connie Benton Wolfe, executive director of The National Association of Nutrition Aging Services, stated she expected participation in Meals-on-Wheels programs to skyrocket in the next decade. Wolfe also stated that elderly feeding was one of the fastest growing government-subsidized foodservice programs. The number of meals served increased from 166.3 million in 1980 to a projected 250 million for 1988.

Older Americans Act

The Nutrition Program for the Elderly was authorized by Public Law 92-258 in 1972 as a part of the Title VII Older Americans Act. The Act established the Administration on Aging (AoA) to administer the nutrition program (17). The nutrition program was designed to meet the nutritional and social needs of persons aged 60 or older. Emphasis was given to service of meals at congregate sites.

The AoA initially stated that ten percent of the total number of congregate meals could be served to homebound elderly. This percentage was increased to 15 percent in 1974 to allow more flexibility for local nutrition projects. If greater than 15 percent home delivered meals was needed, the local project could petition the State agency to increase the number of people served in their homes (18).

In 1978 authorization for nutrition services was changed from Title VII to Title III, Part C of the Older Americans Act (3). Title III-C authorized government sponsored congregate and home delivered nutrition services. Subpart 2 of Title III-C of the Older Americans Act delineated home delivered nutrition services, which established home delivered nutrition projects for older individuals. Subpart 2 allowed for the provision of at least one home delivered hot, cold, frozen, dried, canned, or supplemental meal per day, five or more days a week. Each meal was to provide a minimum of one-third of the daily recommended dietary allowances as established by the Food and Nutrition Board of the National Academy of Sciences National Research Council. Client income was not be a factor in determining eligibility for federally funded meal programs (3). Posner (15) reported that the home delivered meal portion of Title III-C of the Older Americans Act was designed to deliver meals five days a week in urban settings and one to three days a week in less densely populated settings.

Funded Delivered Meal Programs

Privately Funded Programs

Private, nonprofit programs for home-delivered meals are community services administered by community officials, or voluntary health or welfare agencies. Their services are provided to ill, disabled, and elderly persons, or other persons whose physical, emotional, mental, or social conditions inhibit their ability to obtain or prepare adequate meals for themselves (12). Client

ability to pay determines program participation in private home delivery programs since clients must reimburse the program for services provided (15). Private delivery services frequently operate in locations where Title III-C home delivered meals are not offered (19).

Schlenker (20) indicated that privately funded home delivered meals are usually delivered by volunteers who pay their own transportation costs. Frequently, the programs are associated with a nonprofit community organization. Private programs are not subject to federal regulations regarding program participants or nutritional content of meals served. These programs receive no federal funds under Title III-C. Sources of income for private programs are private contributions, community funding such as the United Way, and fees from recipients. Completely voluntary programs are more often located in suburban communities or rural areas.

Federally Funded Programs

One or more meals a day up to seven days a week are provided in federally funded home delivery programs without regard to client income (15). Adherence to federal regulations regarding clients served and meal frequency and quality is required upon acceptance of federal funds. Title III-C delivery personnel are usually reimbursed for both time and mileage (20).

Acceptance of Frozen Meals

Lyons (6) instituted a program in New Hampshire in 1982 whereby homebound elderly received two frozen meals for use on the weekend along with their regular Friday hot meal. Prior to the use of frozen meals, these elderly had been receiving canned food to reheat on the weekend. Evaluation of the program revealed that the elderly resented the effort involved in reheating frozen meals.

Osterraas et al. (7) tested alternative approaches to home delivered meals by designing frozen meals for delivery. Thirty-three elderly rated hot home delivered meals received in the past and frozen meals prepared and delivered weekly for this study. Over four-fifths of the respondents rated the frozen meals equal to or superior to hot meals on all five qualities tested: taste, texture, appearance, convenience, and healthfulness.

Yarrow (8) interviewed home bound elderly to compare acceptability of hot home delivered meals with home delivered frozen meals prepared at the same congregate meal site. Over three-fourths of the clients reported ratings of "okay" or "good" for flavor, appearance, texture, variety, containers, and degree of doneness for both hot and frozen meals. She found that the main advantage of hot meals was convenience, while the advantage of frozen meals was the availability of specific foods. A 15 percent cost savings was realized with the frozen meals. Yarrow (8) also found that temperatures of all hot foods at the end of the one-hour delivery route were in the microbiological danger zone at final delivery.

Spillman et al. (21) reported on a model feeding program for the elderly whereby 2,000 individually packaged meals a day were prepared and blast frozen. Frozen meals then were distributed to satellite kitchens in a 100-mile radius and heated in the satellite kitchens prior to service to the elderly. Meals were not completely cooked prior to freezing; they finished cooking during the reheating process. Food quality was reported as being high and texture and flavor were good. Because extra meals remained frozen, food was not wasted.

Hazard Analysis Critical Control Points

History

A program was developed in 1965 as a result of a joint effort of the Pillsbury Company, the National Aeronautics and Space Administration, and the U.S. Army Natick Laboratories in order to avoid the possibility of food safety problems developing. The intent of Hazard Analysis Critical Control Points (HACCP) was to apply a zero-defects program to the production of food (9). Curtis and Husky (22) noted that HACCP identified all points in food processing which could be potential hazards to consumer safety and covered the system from incoming raw materials to product distribution. According to Bryan (23) HACCP was currently being used as the investigative activity intended to disclose either the actual presence or possibility of occurrence of potentially hazardous foods, pathogenic foodborne organisms, employee practices, hazardous time-temperature combinations, cross-contamination procedures and hazardous

environmental conditions. Taubert (24) identified two parts to the HACCP program: identification of hazards and assessment of critical control points.

Hazard Identification

Taubert (24) reported that hazard identification has been used to prevent food safety problems and adulteration from occurring in finished good products, but it is adaptable to the foodservice industry. He noted two types of hazards inherent in foodservice operations: critical process hazards and physical critical hazards.

He defined critical process hazards as ones in which the food would be unsafe from a microbiological standpoint. These hazards included time/temperature relationships in cooking; freezing, refrigeration, warming, and holding steps; personnel practices; and cleaning and sanitizing procedures (24).

Taubert (24) stated physical critical standards were ones in which hazardous materials, such as metal, glass, or other objects, could be introduced into the product. The area of ingredient storage and the kitchen environment should be inventoried for potential hazards. Bryan (25) stated that establishments of highest concern are those in which foods are prepared in advance of serving, where foods are likely to be stored in a manner which might allow microbial growth, and where reheating temperatures may fail to kill any microbial contaminants generated during improper storage.

Critical Control Points

The second part of the HACCP concept, the identification of critical control points, involves identifying points in the food production process where lack of control could present a potential health danger from the product (26). Unklesbay (27) identified none control points necessary for monitoring microbial qualify and safety within foodservice operations: procurement, storage, packaging, preprocessing, heat processing, storage following heat processing, heat processing of precooked menu items, product distribution, and service.

In a later study, Bobeng and David (28) recategorized Unklesbay's nine items to specify four critical control points for hospital foodservice systems. These were ingredient control and storage, equipment sanitation, personnel sanitation, and time-temperature controls. The reason Bobeng and David (29) gave for not including microbiological parameters was that results of microbiologic analyses would not be available for corrective action until after the food was served.

McCool and Posner (30) listed twelve major safety control points which could be found in foodservice systems for the elderly. These control points were in the areas of: inspection, storage (dry, chilled/frozen), thawing, preparation/initial cooking, hot holding, chilling and holding, freezing and holding, portioning, assembly/packaging, reheating, transportation to sites/homes, and food holding (hot and cold) and service.

Types of Foodservice Systems

Spears and Vaden (31) summarized research on four types of foodservice systems: conventional, commissary, ready prepared, and assembly/serve. In the conventional foodservice system, food is purchased in various stages of preparation, but all production is completed and foods are served on the same premises. Foods are held hot or chilled and served as soon as possible after production.

A commissary type of foodservice system is characterized by a centralized food procurement and production facility, with distribution to remote areas of prepared menu items for final preparation and service. Specialized storage and distribution equipment may be required in commissary systems (31).

Spears and Vaden (31) noted the key difference between ready prepared and conventional systems was that menu items are not produced for immediate service in ready prepared systems. Two variations of the ready prepared systems which they identified were cook-chill and cook-freeze. As the name suggests, food items are stored chilled after production in the cook-chill system and stored frozen, typically from two weeks to three months, in the cook-freeze system.

They stated that in the assembly/serve system, foods were ready to serve or required little or no processing prior to service. This type of system is often referred to as a convenience food system (31).

Critical Control Points Applied to Foodservice Systems

Bobeng and David (28) identified control points for entree production in conventional, cook-chill and cook-freeze hospital

foodservice systems. For conventional foodservice systems control points where lack of control could present a potential health danger occurred during procurement, preparation, heating, hot holding, portioning, assembly, distribution, and service. Control points in the cook-chill foodservice system existed during procurement, preparation, heating, chilling and cold storage, portioning and assembly, cold holding and distribution, microwave heating, and service. In the cook-freeze foodservice system, control points occurred during procurement, preparation, heating, freezing and frozen storage, thawing, portioning and assembly, cold holding and distribution, microwave heating, and service.

Types of Foodservice Systems Used in Elderly Feeding Programs

According to Epp (10), dietitian at the North Central Flint Hills Area Agency on Aging, three types of foodservice systems were being used in the region's 40 congregate meal sites. Approximately two-thirds of the meal sites prepared food using the conventional foodservice system. Fifteen of these meal sites received food catered to their site by a central kitchen, utilizing the commissary type of foodservice system. Often, cook-freeze was incorporated when food remaining following hot holding at both conventional and catered sites was plated and frozen to be delivered to elderly at a future date.

Sanitation Concerns of Foodservice Systems

Incidence of Foodborne Disease

Bryan (32), Chief of Foodborne Disease Training for the U.S. Department of Health and Human Services at the Center for Disease

Control, summarized practices which were frequent contributors to outbreaks of foodborne disease. These practices, in order of frequency of occurrence, were: improper cooling of foods, lapse of a day or more between preparing and serving food, infected persons having handled foods that were not subsequently heat processed, inadequate time-temperature exposure during heat processing of foods, insufficiently high temperatures during hot storage of foods, inadequate time-temperature exposures during reheating of previously cooked foods, and ingestion of contaminated raw foods or raw ingredients.

Snyder (33) classified practices which were frequent contributors to outbreaks of foodborne disease into six process categories: cold holding, food cooling, hot holding, heating, personal hygiene, and supply. These factors are seen as critical control points in foodservice systems.

Hazard Analysis

Bryan (23) outlined four goals for hazard analysis in foodservice operations: identify potentially hazardous foods and ingredients which could contain poisonous substances, pathogens, or large numbers of bacteria; locate sources and specific points of contamination through observation at each step of the operation; determine a microorganism's potential for surviving the heating process; and determine a microorganism's potential to multiply at room temperature, and during hot and cold storage. Bryan identified six steps in the

food processing sequence where observations should be made to identify hazards: procurement, preparation, hot-holding, cooling, portioning, and reheating.

Bryan (23) indicated that procurement involved purchasing, receiving, and storage. Foods should be purchased or otherwise obtained from safe sources. Raw foods received may harbor pathogenic microorganisms. Upon receipt, foods should be classified as to whether they are potentially hazardous (those foods which contain nutrients which support growth of pathogenic bacteria), perishable, or shelf-stable. Whichever type of food, it should be stored to avoid situations which could influence contamination or promote multiplication of bacteria.

He stated that preparation of food involves many potential food hazards. Reconstituted dry foods can be contaminated from water, workers' hands, or contaminated vessels during rehydration. Frozen foods which must be thawed prior to cooking may be potential problems if the foods were to be left at room temperature for several hours or kept in refrigerators for several days. Any organisms present on incoming foods may survive if foods are inadequately cooked or served uncooked. There may be a possibility of cross-contamination between raw and cooked foods during preparation (23).

Bryan (23) stated that after the initial cooking process, the conventional and ready prepared foodservice systems differ as to the next process step. Of most crucial concern in all systems, however, were the operations in which there is a lapse of time between cooking and serving. There is little or no hazard of foodborne illness for

most foods if they are eaten soon after cooking. However, as the time lapse between cooking and eating increases, temperature control during the interim becomes a great concern. This holding occurs in the ready-prepared system, but may also occur during prolonged hot holding in the conventional foodservice system. Cross-contamination from raw foods to cooked foods must be monitored during any holding steps.

Bryan (23) contended that hot-holding can be a hazardous operation in a foodservice establishment. During this holding period, foods may be held within the incubation range for pathogenic bacteria due to improperly designed or improperly operated hot-holding equipment.

He indicated that most outbreaks of bacterial foodborne illness occur because cooked foods are improperly cooled. Therefore, cooling is the most critical control point in foodservice. If foods are to be served hours or days later, as in the ready-prepared food systems, they should be refrigerated as soon as post-heating rise has subsided. If foods have been held in hot-holding devices, they should be refrigerated as soon as serving has been completed (23).

Bryan (23) stated that during portioning and assembly of food for service, the workers' hands must be clean so that additional contamination of food does not occur. When foods are packaged to be eaten at some time after having been packaged, subsequent temperature abuse is beyond the control of the foodservice worker. Therefore, this control point is especially important to ensure service of noncontaminated food.

He indicated that reheating is the last line of defense in preventing foodborne disease. It is even more important than the initial cooking. If bacteria have survived cooking, or if there has been post-heating contamination, improper hot-holding, prolonged room temperature storage, or improper chilling, any large population of bacteria which could result must be killed during reheating. Temperatures of food items taken from heating devices must reach 165°F (23).

Time/Temperature Relationships

McCool and Pcsner (30) reported that the cook/satellite and cook/chill or cook/freeze foodservice systems have more time-temperature relationships to monitor than the cook/serve system. They suggested that nutrition services for the elderly, which have more than two hours lapse between the final meal heating and service to the last client, select an alternate foodservice delivery system, such as chilled, frozen, or shelf-stable foods. Nutrient and aesthetic damage occurs to foods during prolonged hot holding and the risk of foodborne illnesses increases. Size of the geographical area of the nutrition project, length of delivery route, heavy traffic, poor rural roads, and adverse weather conditions may significantly increase holding time. The authors suggested an increase in the number of delivery vehicles in order to shorten the delivery route.

McCool and Pcsner (30) also stressed that the fool temperature safety zone must be monitored at all critical control points. In order to reduce the potential for foodborne illness, food should not be within the temperature danger zone (45 - 140°F) for greater than

four hours during the entire foodservice process, from purchase to service, including holding and home delivery.

Longree and Armbruster (34) reported established time/temperature relationships for the refrigeration and freezing of foods. When chilling cooked foods, the warmest part of the food mass should reach 45°F within a time span of four hours, preferably two. The food should not be in the temperature range of 120-60°F for more than two hours. Food for freezing should be placed in small batches so that the food can be solidly frozen within one-half hour of exposure to freezing temperatures. Many institutional freezers may not be capable of freezing foods within one-half hour; however, they might be adequate for storage of already frozen food.

In a presentation at the 1988 Institute of Food Technology Annual Meeting, Glew (35) recommended that a temperature of 23°F be reached within two hours after cooking. Foods produced for cook-freeze catering operations should subsequently be stored at 0°F. He stated that there should be no microbiological problems with cook-freeze processing if the food is reheated directly from 0°F to 158°F.

Food Safety and Elderly Feeding Programs

In 1971, the Administration on Aging (AoA) studied 32 selected Home Delivered Meal Programs to determine characteristics of programs currently in operation. Of the sites studied, 30 programs served cold foods and packaged them in several types of containers. Most frequently used were plastic containers or bags and styrofoam containers with covers. Heavy foil aluminum containers with covers

were most frequently used for hot foods. To transport the food, over two-thirds of the programs placed cold food in paper bags or boxes and hot food in large styrofoam or metal containers. Few programs relied on special procedures to keep the food hot during the delivery. Very few programs checked the temperature of the food (36).

A study was conducted in the Spring of 1980 for the AoA to describe the quality of meals being served with Older Americans Act Title III-C funding. Of the 119 nutrition projects from which data were collected, food from approximately half were sampled for microbiological testing. Results indicated sanitation and food temperature control standards were not being met consistently in individual project sites. Results of microbiological, sanitation, and temperature data indicated that certain project sites were serving food to olderly which could be considered potentially unsafe to eat. Recommendations from the study included the development of food safety training programs for foodservice personnel to assure safer food handling practices from preparation through service (37).

McCool and Posner (30) reported that there were two elements which affect the ease of maintaining safety and sanitation of a foodservice system: the amount and type of food handling and storage time characteristics; and the number, training, and supervision of foodservice workers. Microbial growth is a potential danger when food is prepared at a central location and transported to individual homes as in the home delivered meal program. The authors suggested that ready-prepared food technologies which minimize food handling, such as

frozen, canned, retort pouch, traypack, or freeze-dried products, should be used when a nutrition service provider cannot maintain control over safety and sanitation.

In their recommendations to Congress on the Older Americans Act (38), the American Dietetic Association (ADA) recommended that Congress should "specify minimum standards for food temperature and holding times and compliance with federal, state, and local health and safety laws and regulations." The ADA noted that the cook/serve or cook/satellite foodservice system used by most elderly nutrition projects had more potential stages where food could be contaminated by bacteria than other types of systems, such as cook/chill, cook/freeze, or assembly serve.

Glew (35) reported that organisms can survive freezing temperatures of -18°C, however, they will not grow at that temperature. Therefore, if microorganisms were present following cooking, they may survive the freezing process. Following thawing in the cook-freeze-thaw process, any microorganisms present may grow. This could result in the formation of microbial toxins which could cause poisoning after reheating.

Meal Delivery in Rural Areas

In 1965, the National Council on Aging (12) stated that there was a disproporation of older people in some rural communities, which required innovative solutions to home meal delivery in those areas. In the Spring of 1980, there were approximately 12,000 congregate meal sites, with 64 percent of these projects in rural areas (37).

McCool and Posner (30) stated that food should be held less than two hours after heating, which includes delivery time. Total holding time may be increased by poor rural roads and adverse weather conditions. They suggested that the cook/freeze foodservice system would be appropriate for projects serving more than 300 meals a day, regardless of the length of delivery route.

McCool and Posner (30) identified rising gasoline prices, difficulty in obtaining volunteer drivers, and the increasing number of elderly as reasons to explore more cost-effective methods of food delivery to the elderly. Schlenker (20) suggested that exploration into the possibility of frozen meal delivery in rural areas where daily meal delivery may be prohibited by cost, should be continued.

METHODOLOGY

This research project was conducted in two phases to achieve the research objectives. Phase I was designed to determine freezing procedures used at congregate meal sites. In Phase II, procedures used at congregate meal sites were simulated to determine length of time food remained in the hazardous temperature zone during the freezing process.

Phase I

Sample

The sample for Phase I consisted of managers or lead cooks for all 40 congregate sites in the 18-county North Central Flint Hills Area Agency on Aging region. Names and addresses of managers or cooks at these sites were obtained from the Assistant Director of the Nutrition Program for this region.

Questionnaire Development

A twelve item questionnaire (Appendix A) was developed to assess whether congregate sites were freezing meals for delivery to elderly. The questionnaire was copied on 8½ x 11 blue paper and Kansas State University, the sponsoring organization, was identified at the top of the questionnaire. The first question was designed to divide respondents into two groups: those currently freezing meals and those not using frozen meals.

If meals were being frozen, respondents were directed to the left hand column of the questionnaire and asked to indicate the number of

meals frozen at one time, type of equipment used to freeze meals, approximate freezer temperature, length of time frozen meals were stored, materials used for packaging meals, time of packaging meals, number of meals delivered to each participant, and approximate length of time frozen meals were held during the delivery process. Managers were also asked to indicate their perception of the general acceptability of the frozen meals provided.

If meals were not currently being frozen at that site, participants were directed to the right hand column of the questionnaire and asked to indicate whether they had ever frozen meals at that site. If meals had been previously frozen, respondents were asked to indicate reasons for discontinuing frozen meal service.

Questionnaire Distribution

A cover letter which described the study and asked for participation was sent with a questionnaire to each of the study sample (Appendix B). A postage paid return envelope was also included. Due to the high response rate, no follow-up was conducted.

Phase II

The purpose of Phase II, the freezing process, was to simulate actual freezing procedures at congregate sites. Types of containers for freezing meals and freezers used in this phase were determined based on findings from Phase I. During Phase II, data from two trials were collected on two menus, with identical menus prepared during each trial.

Simulated Freezing Process

The freezing process was designed to simulate procedures used at the North Central Flint Hills Area Agency on Aging congregate sites. Meals were prepared in quantity, packaged in individual divided foil containers and covered. Thermometers were inserted into the entree for temperature recording and meals then were placed in the freezer.

Equipment

Freezers. Three freezers were used to simulate actual storage conditions at the congregate sites: the freezer section of a refrigerator (refrig/freezer), a home-size upright freezer (upright), and an institutional walk-in freezer (walk-in). Two models of refrig/freezers were used during the study due to an equipment malfunction. During trial 1, the 3.44 cubic feet (c.f.) freezer section of a Thormador refrig/freezer was used. When the study was repeated in trial 2, the 1.47 c.f. freezer section of a Hotpoint refrig/freezer was used. The upright was a 10.8 c.f. Frigidaire Deluxe freezer. The walk-in was a 395.76 c.f. Jamison Frostop institutional walk-in which had five-shelf open wire racks along three walls. The entrance to the walk-in freezer was located inside an institutional walk-in refrigerator.

During trial 1, the refrig/freezer and upright were located side-by-side, approximately 63 yards from the tray line. The refrig/freezer used in trial 2 was located in another area approximately 57 yards from the tray line. The walk-in was located approximately 15 yards from the tray line.

Two of the freezers (upright and walk-in) contained other food to simulate actual freezing conditions. Space was made in these freezers to allow for a clear surface on which to place the test meals. The refrig/freezer contained only the meals from this study.

Before data collection began, freezer temperatures were monitored with a freezer thermometer, with a range of -40 to 20°C, at two hour intervals between the hours of 9:00 a.m. and 3:00 p.m. for two consecutive days. Temperatures were recorded on a Freezer Baseline Temperature Recording Form (Appendix C). Mean freezer temperatures were determined for each trial.

Recording Equipment. A Doric Scientific Minitrend 205 Microprocessor (microprocessor) was used to monitor and record internal temperatures in °C of entree items with the use of thermocouples. This microprocessor was used to record temperatures in the refrig/freezer and upright.

Temperatures of meals placed in the walk-in were monitored with a pocket thermometer with a range of -20 to 105°C. Thermometers were inserted into the entree prior to placing it in the freezer and were left in the entree throughout the freezing process.

Pilot of Equipment and Procedures

Probes of the microprocessor were calibrated in ice water to ensure consistent reading prior to the study. Probe placement technique was tested using a commercially frozen roast beef meal which had been heated according to package instructions. Temperature probes were inserted in three locations of the beef slices. The

microprocessor monitored the temperature from each probe as the meal froze. Freezing time was slowest for the probe whose point was placed into the center of the center beef slice. Therefore, the probe was inserted in the middle of each entree during data collection to obtain the most accurate estimate of freezing time.

The microprocessor was preset to record temperatures every five minutes during the pilot study. Because the temperature often changed several degrees during the five minute interval, the recording time was changed to every three minutes for data collection.

Meals

Meals were prepared and frozen on two days during each trial. The menu for day one was oven baked chicken (chicken), mashed potatoes, and corn. The serving of chicken consisted of a leg and thigh piece. The menu for day two was yankee pot roast (pot roast), sliced potatoes, and mixed vegetables. The serving of pot roast consisted of four layers of meat, each approximately ¼ inch thick. Meals were prepared by a trained cook. Following preparation, food items were placed on a steam table for holding until they were packaged into the individual containers.

Data Collection Procedures

Meals were packaged individually in divided foil containers and covered with a foil backed cardboard lid. The internal entree temperature of one meal was taken before meals were transported to the freezers.

Because the refrig/freezer and upright were located next to each other in trial 1, meals to be placed in these freezers were packaged at the same time and transported together on a cart to the freezer location. Microprocessor probes were first inserted into entrees of meals to be placed in the refrig/freezer; meals to be placed in the upright remained at room temperature during this time. Because the refrig/freezer and upright used in trial 2 were in different locations, meals were packaged and transported to each freezer separately. Meals for the walk-in were packaged separately from meals for the other two freezers.

Meals were placed into each freezer in two configurations, single and stacked. In the single configuration (single), a single meal container was placed directly on the freezer shelf. The stacked configuration (stacked) involved three meals placed on top of each other on the freezer shelf. Entree temperature of the middle meal in the stack was monitored.

The microprocessor thermocouple or pocket thermometer bulb was inserted into the thickest portion of the thigh of the chicken or the center slice of the pot roast. The entree temperature when placed in the freezer was recorded. Temperatures then were recorded at three minute intervals until 0°C was reached.

Entree temperatures of meals stored in the refrig/freezer and upright were recorded automatically by the microprocessor. Entree temperatures of meals stored in the walk-in were monitored by the researcher who observed the temperature on the pocket thermometer every three minutes and recorded the temperature on the Entree

Freezing Time/Temperature Recording Form (Appendix D). A stopwatch was used to time the three minute intervals. In order to avoid fluctuation of freezer temperatures due to repeated freezer door opening, the researcher recorded temperature upon entering the freezer, then remained in the freezer for three minutes, taking a second reading before leaving. The researcher then remained out of the freezer for two and on-half minutes before reentering the freezer.

Because the walk-in door would be opened and shut several times during the study, walk-in temperature was monitored at three minute intervals throughout the time the meals were being frozen and recorded on the Entree Freezing Time/Temperature Recording Form (Appendix D). Temperatures of the refrig/freezer and upright were not monitored during the freezing process since the freezer doors remained closed once the meals were placed in the freezer.

No additional hot meals were placed in either the refrig/freezer or upright during the data collection period. However, approximately 40 hot meals were placed in the walk-in during trial 1 and 190 meals during trial 2 data collections.

Data Analysis

Programs and routines in the Statistical Analysis System (SAS) were used for all data analysis (39). Data analysis involved computation of frequencies on all variable. Time/temperature plots were generated with time on the horizontal axis and temperature on the vertical axis for each configuration in each freezer for each entree. Means and standard deviations were computed for temperature after

packaging, time from packaging to recording of temperature in the freezer, entree temperature when placed in the freezer, time to reach 0°C, and time in the temperature danger zone after packaging.

RESULTS AND DISCUSSION

Phase I

Phase I questionnaires were returned from 31 (78 percent) of the 40 congregate sites. Responses on freezing practices at congregate sites are summarized in Table 1. Most sites (81 percent) froze meals for later use by their elderly clients. Only one site, which had previously frozen meals, had discontinued this practice. Their reason given for discontinuing the frozen meals was that recipients no longer needed this service.

The quantity of meals frozen at one time was limited at most sites. The greatest percentage (76 percent) indicated they froze less than 10 meals at one time.

The upright freezer, home-size or institutional, was the most commonly used (76 percent). None of the respondents reported using an institutional walk-in freezer.

Most freezers (78 percent) were maintained between 0 and 20°F. Only five (22 percent) maintained freezers at temperatures below 0°F.

The amount of time frozen meals were stored varied between sites. The majority of sites (76 percent), however, held meals for 14 days or less.

Packaging practices at congregate sites are summarized in Table 2. Nearly all of the sites (92 percent) froze meals in a foil tray with either a foil or cardboard cover. Most (88 percent) packaged their meals for freezing after serving the on-site meal.

Table 1. Freezing practices at congregate sites

	N[1]	%
site freezes meals		
yes	25	81
no	6	19
number of meals frozen at one time		
<10	19	76
11-20	5	20
21-30	0	0
31-40	1	4
type of freezer		
upright	19	76
chest	3	12
refrigerator/freezer	3	12
freezer temperature		
0-20 F	18	78
<0 F	5	22
length of time stored		
<3 days	5	20
4-7 days	6	24
8-14 days	8	32
15-21 days	3	12
22-28 days	1	4
>28 days	2	8

[1]N may not equal 25 due to nonresponse

Table 2. Practices for packaging meals for freezing at congregate sites

	N	%
type of freezing container		
foil with cardboard/foil cover	23	92
foam with foam lid	1	4
foam with foil lid	1	4
time of packaging		
after congregate service	22	88
prior to congregate service	2	8
food slightly undercooked	1	4

Delivery practices used at congregate sites are summarized in Table 3. A majority of the congregate sites (84 percent) delivered more than one meal at a time. Delivery of two meals at a time was practiced by 36 percent of the facilities, which may indicate that frozen meals were delivered for weekend use to supplement hot meal delivery during the week. Most sites (84 percent) had delivery routes of 30 minutes or less.

Phase II

Freezer Temperatures

Mean freezer temperatures prior to the study are listed in Table 4. The temperature of the refrig/freezer was in the 0 to 20°F temperature range which was the most common temperature range indicated in Phase I. Upright and walk-in temperatures were below 0°F, which was colder than freezer temperatures indicated by the majority of congregate site managers.

Walk-in freezer temperature during trial 1 remained below -18°C (0°F). During trial 2, the researcher noted that the walk-in was on the defrost cycle for a portion of the freezing time, resulting in mean freezer temperatures 9°C warmer than those recorded before the study began.

Time/Temperature Relationships from Packaging to Freezer

Temperatures of entrees taken immediately after packaging are summarized in Table 5. The mean temperature of chicken was 11.5 to 18.5°C warmer than the mean temperature of pot roast. The temperature of the pot roast was consistently below the recommended level of 60°C

Table 3. Practices for home delivery of frozen meals at congregate sites

	N	%
number of meals delivered at one time		
1	4	16
2	9	36
3	1	4
4	2	8
5	3	12
>5	6	24
length of time on delivery route		
<15 minutes	11	44
15-30 minutes	10	40
31-45 minutes	4	16

Table 4. Mean freezer temperatures before data collection

freezer	temperature			
	trial 1		trial 2	
	(°C)	(°F)	(°C)	(°F)
refrigerator/freezer	-10.2	+13.6	-11.9	+10.6
upright	-25.4	-13.8	-25.8	-14.5
walk-in	-23.5	-10.3	-23.1	- 9.6

Table 5. Entree temperature after packaging

menu item freezer	temperature		
	trial 1	trial 2	mean st dev.
	----------°C----------		
chicken			
refrig/freezer	66	67	66.5 ±0.71
upright	66	59	62.5 ±4.95
walk-in	67	57	62.0 ±7.07
pot roast			
refrig/freezer	51	45	48.0 ±4.24
upright	51	53	52.0 ±1.41
walk-in	50	53	51.5 ±2.12

after packaging (40). Entree temperatures varied between trial 1 and trial 2, probably due to variations in entree temperatures prior to packaging.

Length of time from packaging to recording temperature in the freezer is summarized in Table 6. Time to refrig/freezer and upright was from two to ten minutes longer than time to walk-in due to the greater distance between packaging area and these two freezers. Time to upright was greater for trial 1 than for trial 2 because of the side-by-side location of the two freezers in trial 1 and the need to hold the meals for the upright while meals were placed in the refrig/freezer.

Entree temperatures when placed in the freezer are summarized in Table 7. Mean temperature for chicken was 6.5 to 22°C warmer than the pot roast in the single configuration and 11 to 14°C warmer in the stacked configuration.

The drop in temperature from packaging (Table 5) to freezer (Table 7) was less for entrees placed in the walk-in, probably because of the shorter length of time between packaging and freezer placement (Table 6). The temperature loss was less for the chicken than the pot roast probably because of the chicken's density, which held heat longer. Dorney and Glew (41) indicate that density of the food affects its ability to hold heat; denser foods hold heat longer.

Entree Temperatures During Freezing

Entree temperatures recorded during the freezing process are listed in Tables 10 to 15 in Appendix E, by entree item, freezer,

Table 6. Time from packaging to recording of temperature in freezer

menu item freezer	time		
	trial 1	trial 2	mean st. dev.
	----------minutes----------		
chicken			
refrigerator/freezer	8	7	7.5 ±0.71
upright	12	5	8.5 ±4.95
walk-in	2	3	2.5 ±0.71
pot roast			
refrigerator/freezer	8	5	6.5 ±2.12
upright	11	5	8.0 ±4.24
walk-in	6	3	4.5 ±2.12

Table 7. Entree temperature when placed in freezer

menu item freezer	temperature					
	trial 1		trial 2		mean (st. dev.)	
	single[1]	stacked[2]	single[1]	stacked[2]	single[1]	stacked[2]
	°C					
chicken						
refrig/freezer	67	66	54	51	60.5 ± 9.19	58.5 ±10.61
upright	63	55	62	58	62.5 ± 0.71	56.5 ± 2.12
walk-in	63	63	56	53	59.5 ± 4.95	58.0 ± 7.07
pot roast						
refrig/freezer	46	43	41	46	43.5 ± 3.54	44.5 ± 2.12
upright	44	39	37	48	40.5 ± 4.95	43.5 ± 6.36
walk-in	53	47	53	47	53.0 ± 0.00	47.0 ± 0.00

[1]single meal placed directly on freezer shelf

[2]meals stacked three deep on freezer shelf; temperature monitored for center meal

configuration, and trial. Figures 1 to 8 depict this same information. Due to recording equipment malfunctions during trial 1, temperatures of the chicken were not recorded until seven minutes after being placed in the freezer. Temperatures were recorded at approximately three minute intervals from that time.

Freezing Times

Figures 1 to 8 represent the temperature of the entree in °C and time in minutes. Horizontal lines on each figure indicate the temperature danger zone, 7 to 60°C.

Baked Chicken - Single Configuration. Time/temperature summaries of chicken placed in the single configuration are listed in Tables 10-12 in Appendix E and depicted in Figures 1 and 2. The temperature of the chicken when placed in the freezer varied between the two trials, with chicken in trial 1 having the same or a higher temperature than chicken in trial 2 in all freezers.

In trial 1 (Figure 1), chicken placed in the refrig/freezer took the longest amount of time (100 min.) to exit the temperature danger zone; chicken placed in the upright took the shortest length of time (52 min.). One possible explanation for these differences was the freezer temperatures. The upright was 14°C cooler than the refrig/freezer. Dorney and Glew (41) stated that the freezer ambient temperature is one of two control factors in the freezing stage of the cook/freeze system.

The results of trial 2 (Figure 2) differ, however. Chicken in all freezers in the single configuration exited the temperature danger

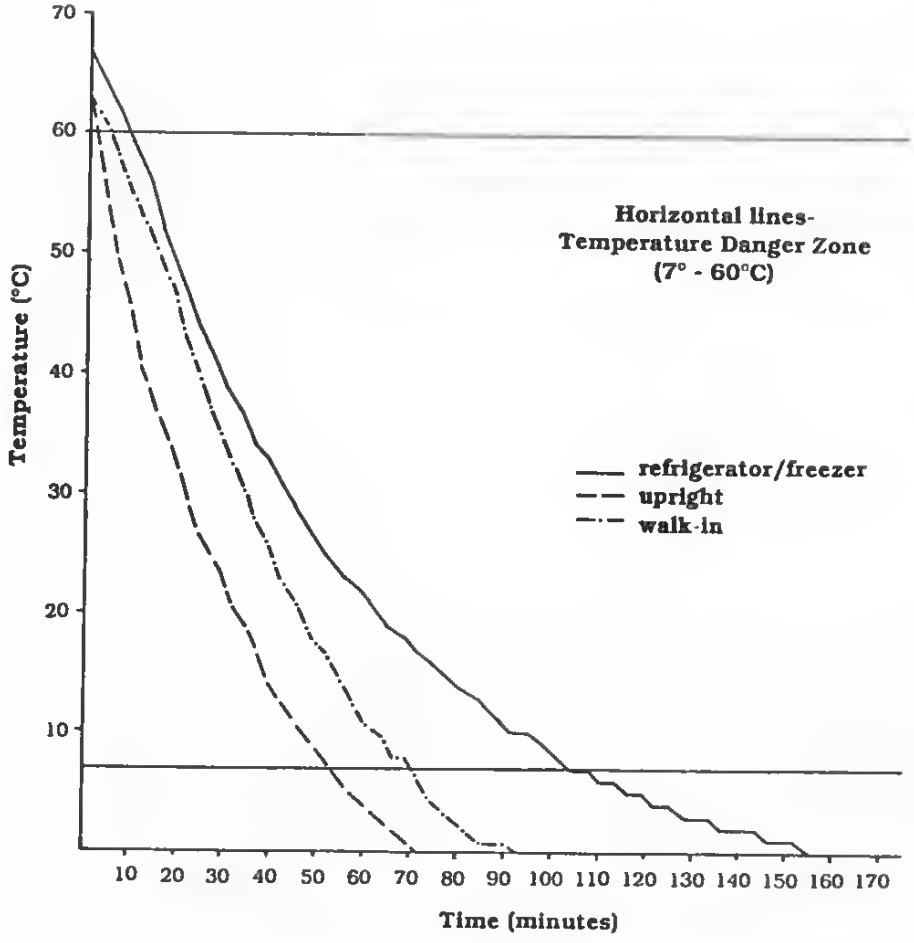

Figure 1. Time/temperature relationship of single baked chicken meal placed directly on freezer shelf (Trial 1)

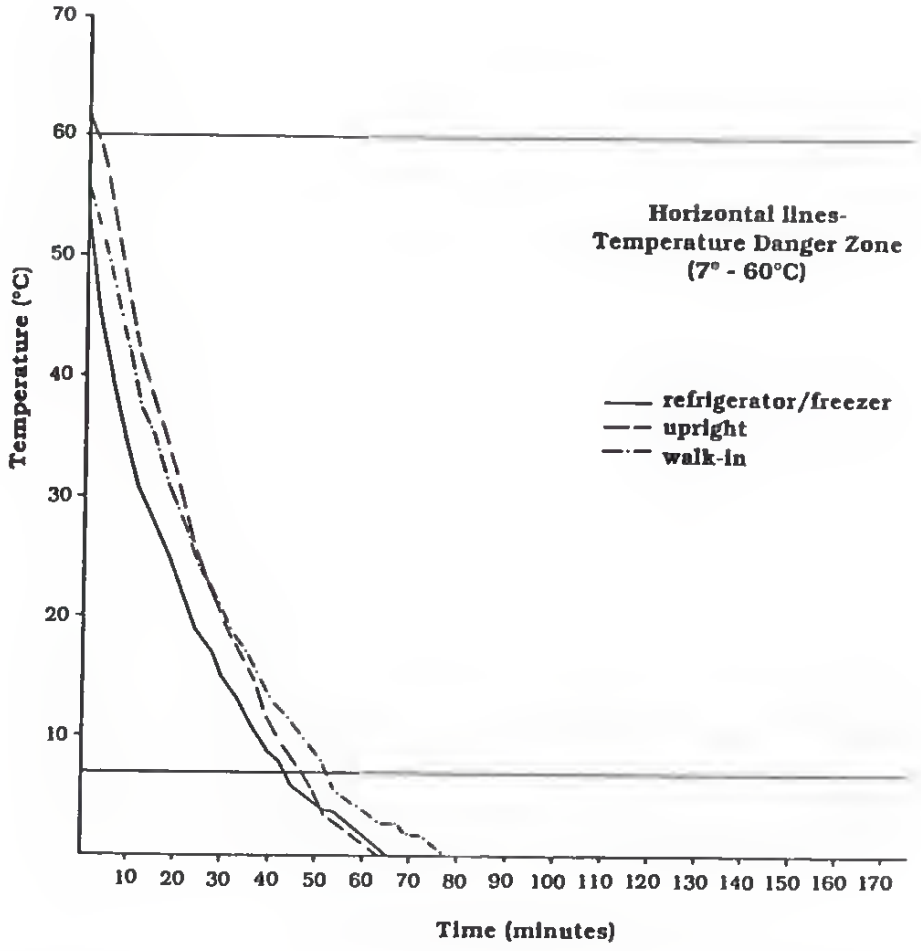

Figure 2. Time/temperature relationship of single baked chicken meal placed directly on freezer shelf (Trial 2)

zone within nine minutes of each other, with the chicken in the refrig/freezer and upright exiting the fastest (45 min. each) and chicken in the walk-in exiting the slowest (54 min.). Three factors may have contributed to this finding: chicken placed in the refrig/freezer was 10 degrees cooler than the chicken placed in the upright, the walk-in temperature was warmer because of the defrost cycle, and 150 more hot meals were added to the walk-in in trial 2 than were added in trial 1.

Baked Chicken - Stacked Configuration. Tables 10-12 in Appendix E and Figures 3 and 4 show the temperature summary of chicken in the stacked configuration for trials 1 and 2. Three meals were stacked and temperatures for the entree of the center meal were recorded. Chicken in the stacked configuration took 22 to 67 minutes longer in trial 1 (Figure 3) and 30 to 77 minutes longer in trial 2 (Figure 4) to exit the temperature danger zone than the single chicken in that same freezer (Figures 1-2). These findings are consistent with that of Bryan (25) and Bryan and McKinley (42) who stated that freezing time can be reduced by freezing food in the single configuration.

Chicken placed in the upright exited the temperature danger zone in the shortest amount of time (90-111 min.); chicken in the refrig/freezer took the longest amount of time (123-167 min.). Chicken stacked in the refrig/freezer in trial 1 remained in the temperature danger zone 47 minutes longer than the two hour maximum time recommended (34). Stacked chicken in the walk-in in trial 2

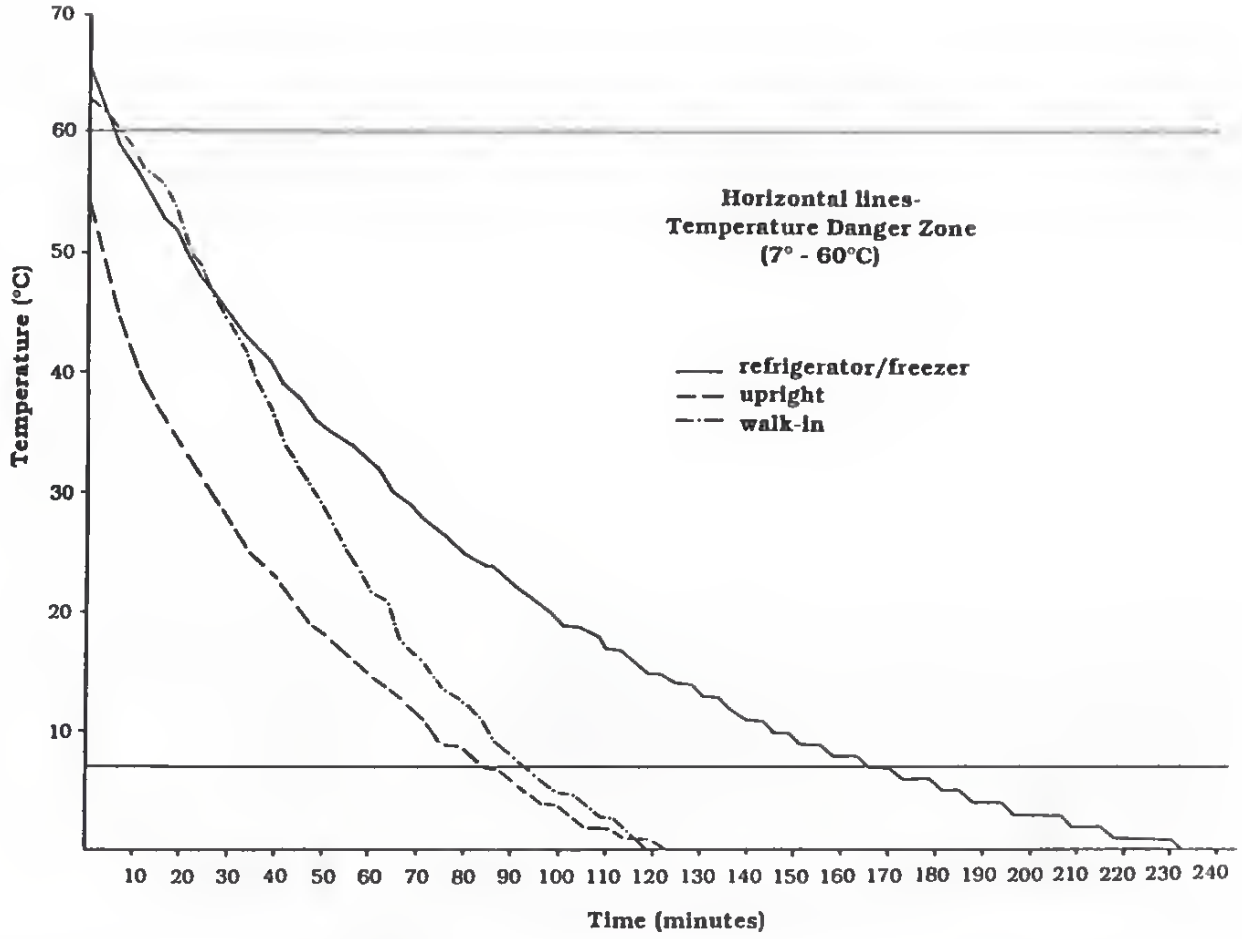

Figure 3. Time/temperature relationship of baked chicken meal stacked three deep on freezer shelf (Trial 1)

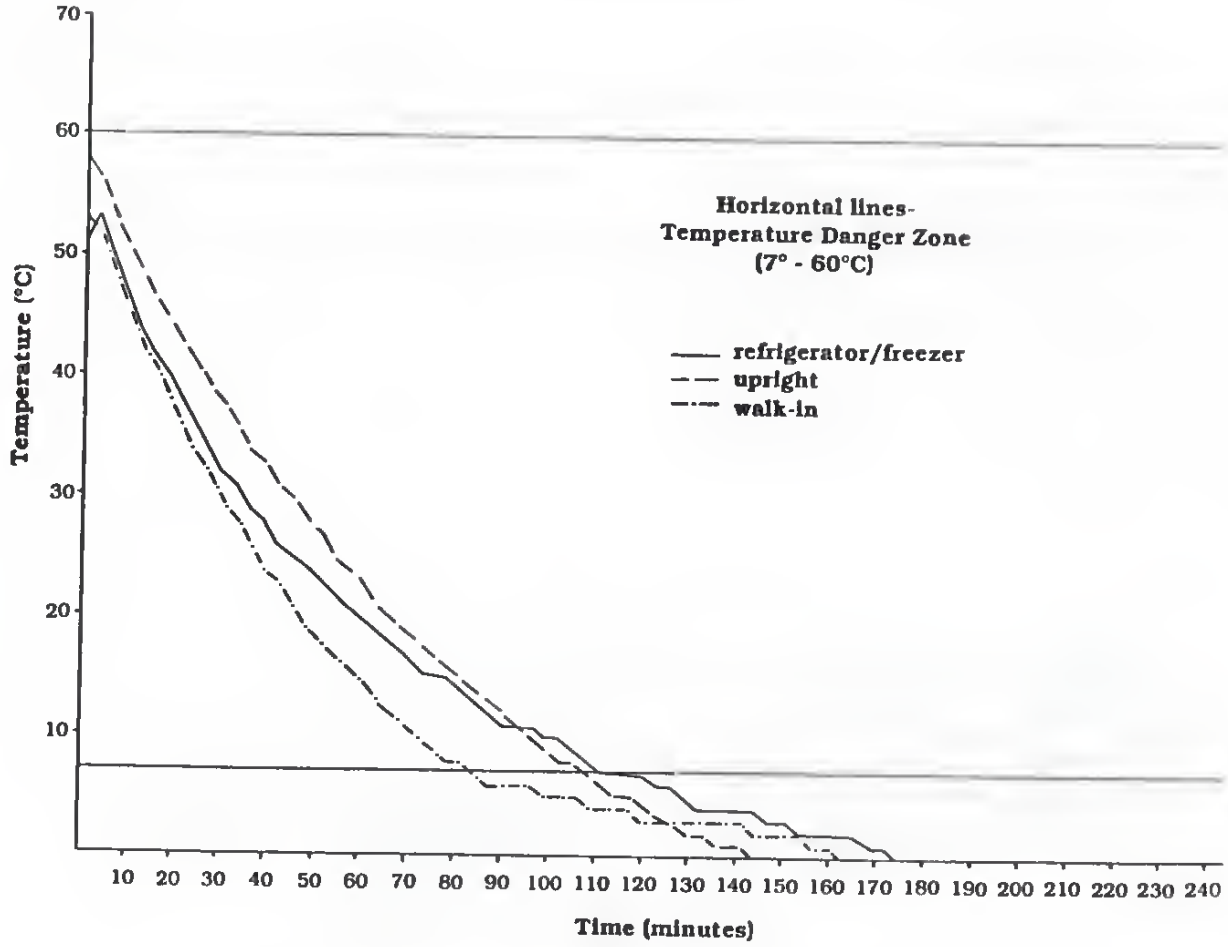

Figure 4. Time/temperature relationship of baked chicken meal stacked three deep on freezer shelf (Trial 2)

exited the temperature danger zone in 83 minutes; however, due to the defrost cycle, the chicken took and additional 80 minutes to drop the final seven degrees to 0°C.

Yankee Pot Roast - Single Configuration. Freezing times of pot roast placed in the single configuration in each freezer are listed in Tables 13-15 in Appendix E and depicted in Figures 5 and 6. Pot roast temperature when placed in the freezer was 7 to 16°C cooler for the refrig/freezer and upright than the walk-in for both trials. Pot roast temperature was in the temperature danger zone upon placement in all freezers in both trials. Pot roast in all three freezers exited the temperature danger zone within one hour for both trials. Pot roast in the upright exited the temperature danger zone in the shortest length of time (12-27 min.), however, this freezer was 1.9 to 15.2°C cooler than the other two freezers.

Pot roast placed in the walk-in began at the warmest temperature in trial 1 (53°C) but had a more rapid temperature drop than the meal in the refrig/freezer because of the walk-in's colder temperature (Figure 5). The researcher noted that the walk-in was in the defrost cycle during trial 2, which resulted in a warmer freezer temperature than was recorded at the beginning of the study. This elevated temperature may have contributed to the longer freezing time (54 min.) for the pot roast in trial 2 (Figure 6). Pot roast placed in the walk-in was from 12 to 16°C warmer than the pot roast placed in the other two freezers which also may have contributed to the longer freezing time.

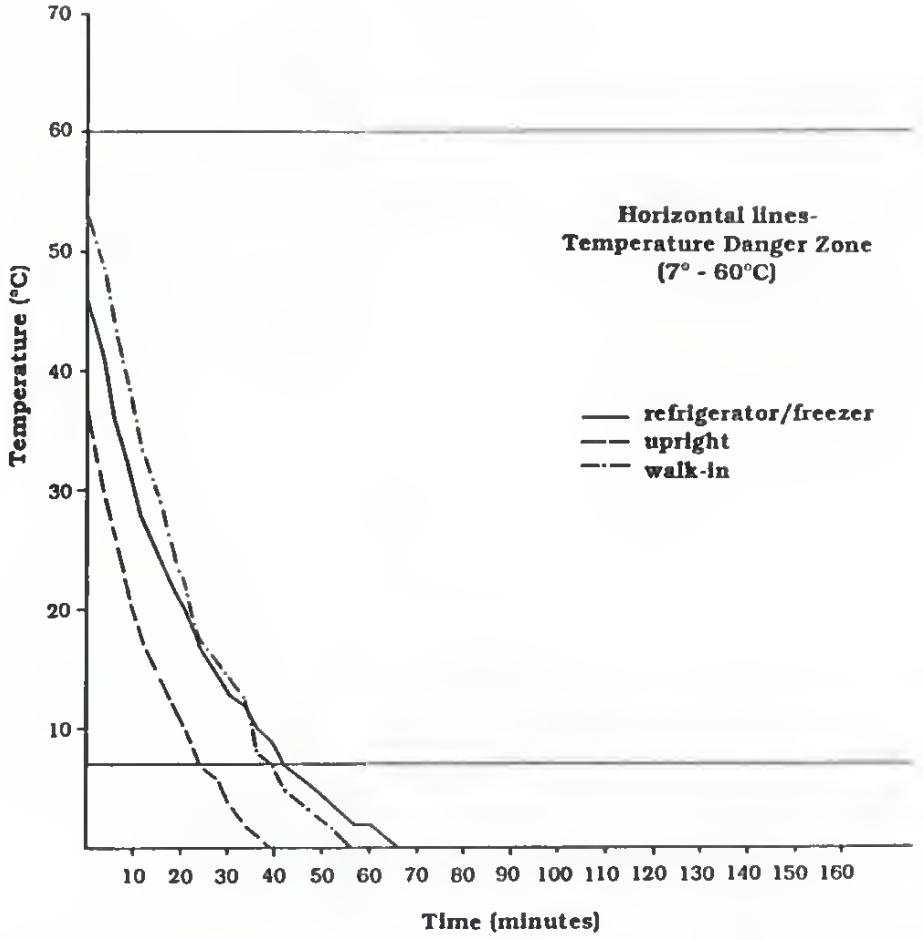

Figure 5. Time/temperature relationship of single yankee pot roast meal placed directly on freezer shelf (Trial 1)

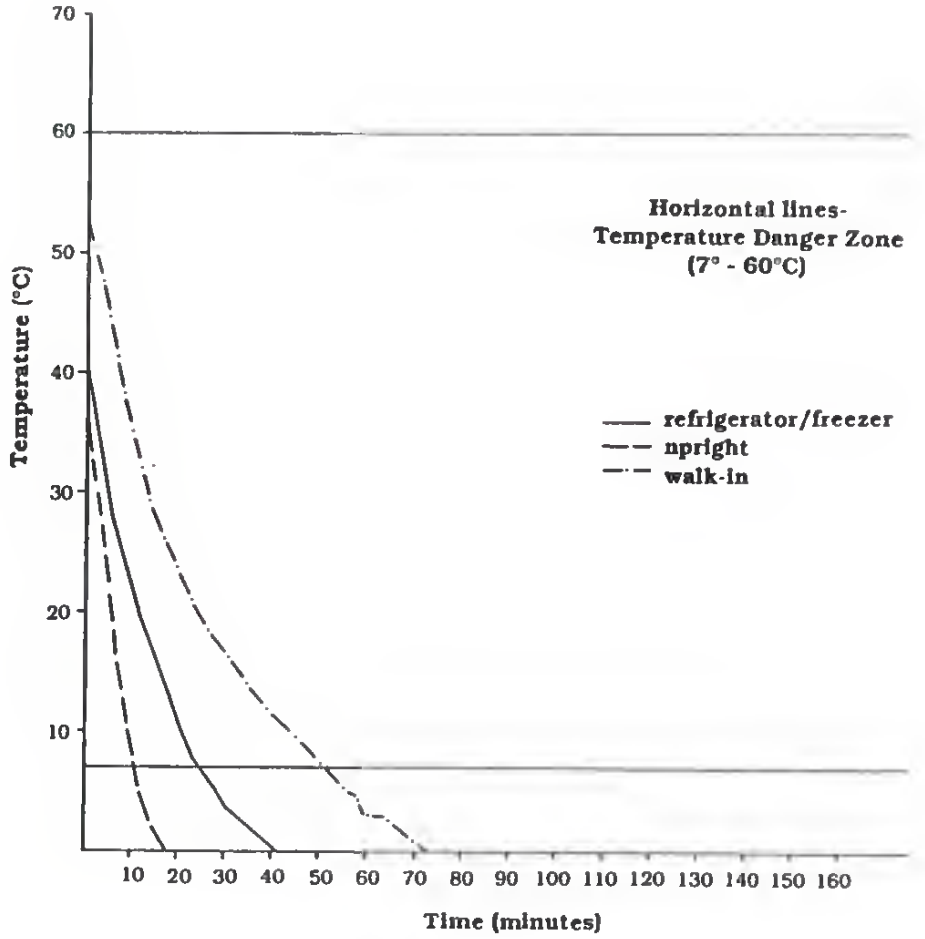

Figure 6. Time/temperature relationship of single yankee pot roast meal placed directly on freezer shelf (Trial 2)

Compared to chicken in the single configuration (Figures 1 and 2), pot roast was in the temperature danger zone for a shorter period of time. However, temperature of the pot roast when placed in all freezers was 3 to 26°C cooler than that of the chicken. Also, the chicken thigh was thicker than the slices of beef. Dorney and Glew (41) also noted a faster freezing time for thin products versus thick products.

Yankee Pot Roast - Stacked Configuration. Temperature summaries of yankee pot roast in the stacked configuration are listed in Table 13-15 of Appendix E and depicted in Figures 7 and 8. Stacked meals (Figure 7) in trial 1 took 10 to 56 minutes longer to exit the temperature danger zone than did single meals (Figure 5), and from 25 to 59 minutes longer in trial 2 (Figure 6, 8). The longer time for the stacked meals was probably due to the insulating effect of the meals which surrounded the center meal. The stacked meal in the walk-in exited the temperature danger zone in the least amount of time (51-78 min.) in trial 1 even though its beginning temperature was 4 to 7°C warmer than the meals in the other freezers. Circulating air in the walk-in may have chilled foods more rapidly than the still air of the other two freezers. Dorney and Glew (41) indicated that very little heat exchange occurs in still air because of the insulating effect of layers of air at the surface of the food package. They state that circulation of air strips away insulating layers and increases the rate of heat transfer.

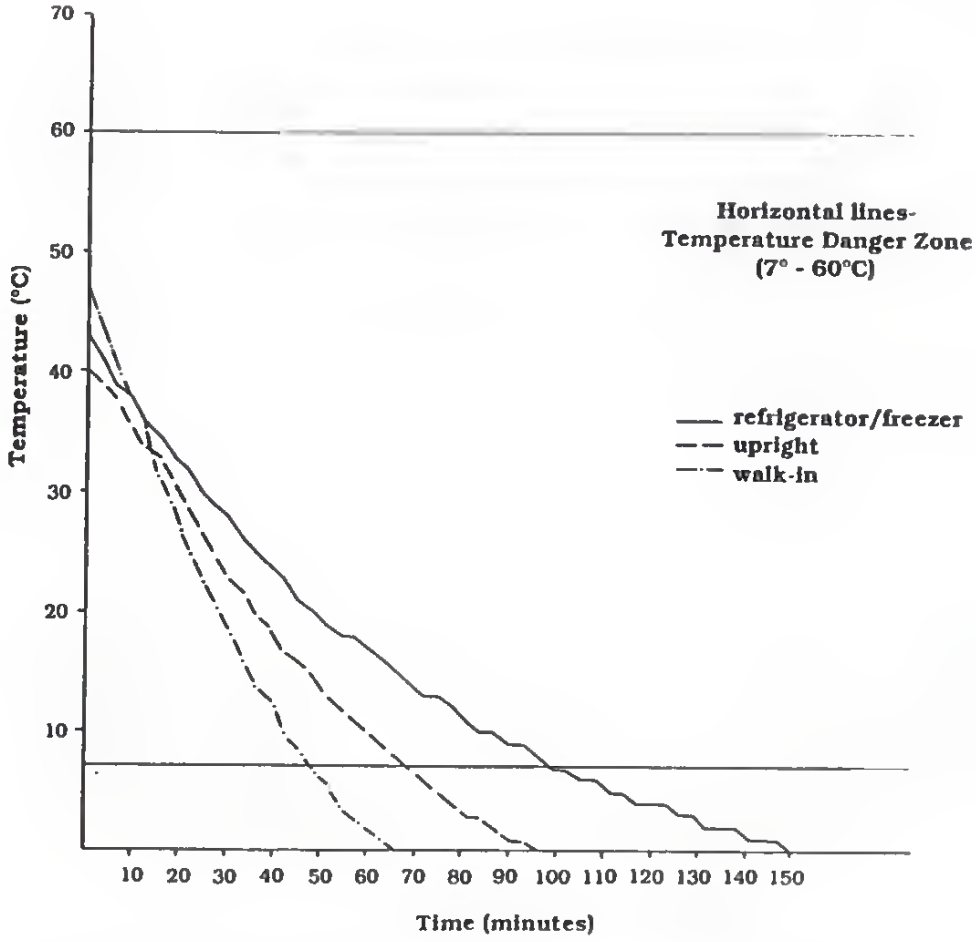

Figure 7. Time/temperature relationship of yankee pot roast meal stacked three deep on freezer shelf (Trial 1)

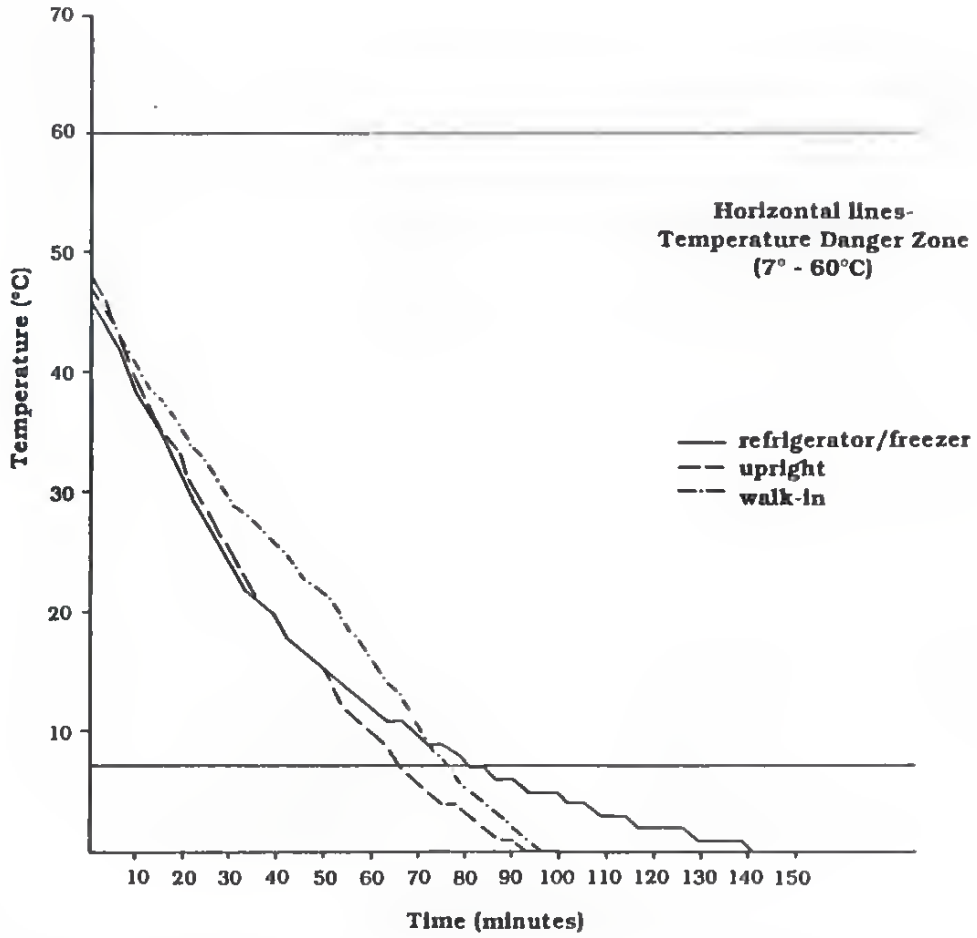

Figure 8. Time/temperature relationship of yankee pot roast meal stacked three deep on freezer shelf (Trial 2)

Compared to the chicken stacked three deep (Figures 3 and 4), the pot roast remained in the temperature danger zone for a shorter period of time (9-62 min.). However, the temperature of the pot roast when placed in the freezer also was 6 to 23°C cooler than the chicken in all freezers, in both trials.

Time/Temperature Relationships

Mean times to reach 0°C in all freezers are listed in Table 8. When stacked, chicken took almost twice as long to reach 0°C than when placed singly on the freezer shelf in all three freezers. Pot roast also cooled more slowly when stacked. These findings support work by Dorney and Glew (41) who reported a faster freezing time when food was in direct contact with the freezing surface. None of the meals were solidly frozen within the one-half hour freezing time recommended by Longree and Armbruster (34) with the exception of the single pot roast meal placed in the upright in trial 2.

Mean time meals in the temperature danger zone after packaging are listed in Table 9. Time in the temperature danger zone was much longer for stacked meals than for singly placed meals for both chicken and pot roast in all freezers. The pot roast exited the temperature danger zone much quicker than did the chicken. Such results can probably be attributed to the difference in product density and temperature when placed in the freezer. Time to exit the temperature danger zone was within the two hours recommended by Longree and Armbruster (34) for all meals except the stacked chicken in the refrig/freezer in both trials.

Table 8. Mean time to reach 0°C after meals placed in freezer

freezer configuration	menu item: chicken	menu item: pot roast
	mean time (minutes) ±st. dev.	
refrig/freezer		
single[1]	110.5 ±62.93	54.0 ±16.97
stacked[2]	203.5 ±41.72	145.5 ± 6.36
upright		
single	67.5 ± 6.36	28.5 ±14.85
stacked	132.0 ±16.97	94.5 ± 2.12
walk-in		
single	85.5 ±10.61	64.5 ±10.61
stacked	142.5 ±27.58	81.0 ±21.21

[1] single meal placed directly on freezer shelf

[2] meals stacked three deep on freezer shelf; temperature monitored for center meal

Table 9. Mean time in temperature danger zone (7 to 60°C) after meals placed in freezer[1]

freezer configuration	menu item: chicken	menu item: pot roast
	mean time (minutes) ±st. dev.	
refrig/freezer		
single[2]	72.5 ±38.89	36.0 ±12.73
stacked[3]	144.5 ±30.41	96.0 ±12.73
upright		
single	48.5 ± 4.95	19.5 ±10.61
stacked	100.5 ±14.85	70.5 ± 2.12
walk-in		
single	60.0 ± 8.49	48.0 ± 8.49
stacked	87.0 ± 0.00	64.5 ±19.09

[1]many items were in the temperature danger zone at time of packaging

[2]single meal placed directly on freezer shelf

[3]meals stacked three deep on freezer shelf; temperature monitored for center meal

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

The population of rural elderly in Kansas is increasing (1). Research to determine the acceptability by elderly of hot and frozen home delivered meals has been conducted by several authors (4-7). Gatherer (4) and Cairns and Caggiula (5) identified problems associated with hot home delivered meals. Osteraas, et al. (7) and Yarrow (8) reported acceptance of frozen meals; Lyons (6) reported dissatisfaction.

Several congregate sites in Kansas provide home delivery of frozen meals to the elderly. Research had not been conducted on the time these meals were in the temperature danger zone during the freezing process.

This study was conducted to determine time/temperature relationships in freezing individually packaged meals used in home bound elderly feeding programs. Specific objectives of the study were to investigate impact on freezing time of meal arrangement in the freezer and examine if freezing time was related to freezing equipment.

Phase I determined freezing procedures used at the 40 congregate meal sites in the 18-county North Central Flint Hills Area Agency on Aging region. Questionnaires returned from 31 managers/cooks provided information on freezing procedures at these sites.

Phase II simulated the actual freezing procedures from the congregate sites. Two menus were prepared by a trained cook.

Temperatures of the entrees (chicken or pot roast) were monitored for this study. Meals were packaged into individual divided foil containers, covered, and placed in one of three freezers: refrig/freezer, upright, or walk-in. Meals were placed in each freezer in two configurations: a single meal placed directly on the freezer shelf, or a stack of three meals placed on top of each other with the temperature of the center meal being monitored. Entree temperatures were recorded at three minute intervals from the time the meals were placed in the freezer until the internal temperature reached 0°C. Two trials of the simulated freezing process were conducted.

Results of the Phase I questionnaire indicated 80 percent of the sites froze meals. Over three-fourths of the sites froze less than 10 meals at one time in an upright freezer which maintained a temperature between 0 and 20°F.

Results of the Phase II simulated freezing process indicated that stacked chicken took 22 to 77 minutes longer to exit the temperature danger zone than did chicken in the single configuration. Stacked chicken in the refrig/freezer took 3 to 47 minutes longer than the recommended two hours to exit the temperature danger zone.

Pot roast usually exited the temperature danger zone in less time than the chicken in all freezers and configurations; however, the temperature of the pot roast when placed in the freezer was 6.5 to 22 degrees cooler than the chicken. In all freezers, stacked pot roast took 10 to 59 minutes longer to exit the temperature danger zone than pot roast in the single configuration in the respective freezer.

Conclusion and Recommendations

Results of this study indicate that freezers which maintain temperatures above 0°F may have difficulty freezing meals within a two hour period, thus, congregate managers should monitor freezer temperatures and strive for temperatures at or below 0°F in order to freeze meals as quickly as possible. Results of this study also demonstrated that meals which are stacked take considerably longer to exit the temperature danger zone than those placed singly on the shelf, especially in the refrig/freezer and upright. Because many of the congregate sites indicated using these two types of freezers, consideration should be given to freezing meals in a single layer directly on the freezer shelf. This recommendation becomes most important when the food item being frozen is dense and would tend to hold heat longer.

Further research is needed on time/temperature relationships of meals frozen in actual congregate sites to determine length of time in the temperature danger zone. Parameters of interest would be the effect on freezing time of stacking more than three meals and the effect of increasing the number of meals placed in the freezer at one time.

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APPENDICES

APPENDIX A

Questionnaire

KSU
KANSAS STATE UNIVERSITY

Department of Hotel, Restaurant, Institution Management and Dietetics

Justin Hall
Manhattan, Kansas 66506
913-532-5521

PREPARATION OF FROZEN MEALS FOR HOME DELIVERY

Please circle your responses

1. Does your facility currently prepare frozen meals for delivery to elderly?

___ Yes

If YES, please answer the questions below.

2. Approximate number of frozen meals frozen daily.
   1. Less thsn 10 mesls
   2. 11-20 mesls
   3. 21-30 meals
   4. 31-40 meals
   5. Greater than 40 meals

3. Number of meals delivered to clients at one time.
   1. 1
   2. 2
   3. 3
   4. 4
   5. 5
   6. Other (please specify)

      _____

4. When is food plsced into freezing containers?
   1. Food slightly undercooked prior to packaging
   2. Food packaged just prior to aerving on-site meals
   3. Food packaged sfter serving on-site meals
   4. Food prepared specifically for packaging as frozen meals
   5. Other (plesse specify)

      _____

      _____

Please turn over to complete.

___ No

If NO, please answer the questiona below.

1. Has your facility ever prepared frozen meals?
   1. yes
   2. no

2. If YES, what wss the reason for discontinuing frozen meal preparation?
   1. Too time consuming
   2. Not adequate freezer space
   3. Not acceptsble to elderly
   4. Other (please specify)

      _____

      _____

      _____

      _____

Thank you for your cooperation. Please return the queationnaire in the enclosed envelope.

5. Type of freezing container.
   1. Foam type dish with foil cover
   2. Foil tray with foil cover
   3. Foil tray with cardboard cover
   4. Other (plesae specify)

      _____
      _____

6. Type of freezer used to store frozen meals in your facility.
   1. Upright home-size freezer
   2. Chest home-size freezer
   3. Walk-in freezer

7. Approximate freezer temperature.
   1. 20^{o} F to 32^{o} F
   2. 0^{o} F to 20^{o} F
   3. Colder than 0^{o} F

8. Approximate length of time food is held frozen prior to delivery.
   1. Less than 3 days
   2. 4 to 7 dsya
   3. 8 to 14 days
   4. 15 to 21 days
   5. 22 to 28 days
   6. Greater than 28 days

9. Type of container used to hold frozen meals during transportation.
   1. Cardboard box
   2. Styrofoam ice chest
   3. Coleman type ice chest
   4. Other (please specify)

      _____
      _____

Plesse continue to next column.

10. Average length of time on delivery route.
    1. Less than 15 minutes
    2. 15 to 30 minutes
    3. 31 to 45 minutes
    4. 46 minutes to 1 hour
    5. Greater than 1 hour

11. What is your perception of the general acceptability of your frozen meals?
    1. No complaints
    2. Generally acceptable, a few minor complaints
    3. Generally unacceptable, many complaints
    4. Asked to discontinue delivery of frozen meals

12. Pleaae provide sny comments you have regarding preparation, delivery, or acceptance of frozen meals.

    _____

    _____

    _____

    _____

Thank you for your cooperation. Please return the questionnaire by April 15, 1988.

APPENDIX B

Cover Letter

KSU
KANSAS STATE UNIVERSITY

Department of Hotel, Restaurant, Institution Management and Dietetics

Justin Hall
Manhattan, Kansas 66506
913-532-5521

March 25, 1988

Dear Congregate Meal Supervisor:

In the Department of Hotel, Restaurant, Institution Management and Dietetics at Kansas State University we are doing research on the preparation of frozen mesls in congregate meal facilities for delivery to elderly. I am requesting your assistance to determine procedures used when preparing frozen meals.

I would appreciate you taking approximstely ten minutes of your time to complete the enclosed questionnaire. If your facility has never prepared frozen meals for delivery, please indicate that on the form and return it. This information is important also. After completing the questionnaire, return it in the enclosed postage paid envelope. I would appreciate receiving your response by April 15, 1988.

The code number on the questionnaire is for followup purposes only. Your facility will not be connected to the results in any way.

Thank you for taking time from your busy schedule to complete the questionnaire. Your help is greatly appreciated.

Sincerely,

Cheryl Thole
Graduate Student

Mary B Gregoire

Mary B. Gregoire, Ph.D., R.D.
Assistant Professor

APPENDIX C

Freezer Baseline Temperature Recording Form

FREEZER BASELINE TEMPERATURE
RECORDING FORM

DATE _____

	Refrigerator/ Freezer	Upright	Walk-In
9:00 a.m.			
11:00 a.m.			
1:00 p.m.			
3:00 p.m.			

DATE _____

	Refrigerator/ Freezer	Upright	Walk-In
9:00 a.m.			
11:00 a.m.			
1:00 p.m.			
3:00 p.m.			

APPENDIX D

Entree Freezing Time/Temperature Recording Form

ENTREE FREEZING TIME/TEMPERATURE

FREEZER _____

DATE _____

FOOD ITEM _____

	Single	Stacked 3 deep	Freezer Temp.
	Probe # ___	Probe # ___	
# of Min	Temp (^{o}C)	Temp (^{o}C)	Temp (^{o}F)
0			
3			
6			
9			
12			
15			
18			
21			
24			
27			
30			
33			
36			
39			
42			
45			
48			
51			

ENTREE FREEZING TIME/TEMPERATURE

FREEZER _____

DATE _____

FOOD ITEM _____

	Single	Stacked 3 deep	Freezer Temp
	Probe # ___	Probe # ___	
# of Min	Temp (^{o}C)	Temp (^{o}C)	Temp (^{o}F)
54			
57			
60			
63			
66			
69			
72			
75			
78			
81			
84			
87			
90			
93			
96			
99			
102			
105			

ENTREE FREEZING TIME/TEMPERATURE

FREEZER _____

DATE _____

FOOD ITEM _____

	Single	Stacked 3 deep	Freezer Temp
	Probe # ___	Probe # ___	
# of Min	Temp (^{o}C)	Temp (^{o}C)	Temp (^{o}F)
108			
111			
114			
117			
120			
123			
126			
129			
132			
135			
138			
141			
144			
147			
150			
153			
156			
159			

APPENDIX E

Supplemental Tables

Table 10. Time and temperature relationship of baked chicken frozen single and stacked in a refrigerator/freezer[1]

	configuration			
	single[3]		stacked[4]	
time[2]	trial 1	trial 2	trial 1	trial 2
minutes	temperature °C			
0	67	54	66	51
3		45		53
6		40		50
7	62		59	
9		35		47
10	59		57	
12		31		44
13	56		55	
15		28		42
16	52		53	
18		25		40
19	49		51	
21	47	22	50	38
24	44	19	48	36
27	42	17	47	34
30	39	15	45	32
33	37	13	43	31
36	34	11	42	29
39	33	9	41	28
42	31	8	39	26
45	29	6	38	25
48	27	5	36	24
51		4		23
52	25		35	
54		4		22

[1]frozen in freezer section

[2]minutes from time meals were placed in freezer

[3]single meal placed directly on freezer shelf

[4]meals stacked three deep on freezer shelf; temperature monitored for center meal

Table 10. (cont.)

time[2]	configuration			
	single[3]		stacked[4]	
	trial 1	trial 2	trial 1	trial 2
minutes	----------temperature °C----------			
56	23		34	
57		3		21
59	22		33	
60		2		20
62	21		32	
63		1		19
65	19		30	
66		0		18
68	18		29	
69				17
71	17		28	
72				16
74	16		27	
75				15
77	15		26	
78				15
80	14		25	
81				14
84	13		24	13
86	12		24	
87				12
89	11		23	
90				11
92	10		22	
93				11
95	10		21	
96				11
98	9		20	
99				10
101	8		19	
102				10
104	7		19	
105				9

Table 10. (cont.)

time[2]	configuration: single[3] trial 1	single[3] trial 2	stacked[4] trial 1	stacked[4] trial 2
minutes	temperature °C			
108	7		18	8
110	6		17	
111				7
113	6		17	
114				7
116	5		16	
117				7
119	5		15	
120				7
122	4		15	
123				6
125	4		14	
126				6
128	3		14	
129				6
131	3		13	
132				4
134	3		13	
135				4
137	2		12	
138				4
140	2		11	
141				4
143	2		11	
144				4
146	1		10	
147				3
149	1		10	
150				3
152	1		9	
153				2
155	0		9	
156				2
158			8	

Table 10. (cont.)

time[2]	configuration			
	single[3]		stacked[4]	
	trial 1	trial 2	trial 1	trial 2
minutes	temperature °C			
159				2
161			8	
162				2
164			8	
165				2
167			7	
168				1
170			7	
171				1
173			6	
174				0
176			6	
179			6	
182			5	
185			5	
188			4	
191			4	
194			4	
197			3	
200			3	
203			3	
206			3	
209			2	
212			2	
215			2	
218			1	
221			1	
224			1	
227			1	
230			1	
233			0	

Table 11. Time and temperature relationship of baked chicken frozen single and stacked in an upright freezer

time[1]	configuration			
	single[2]		stacked[3]	
	trial 1	trial 2	trial 1	trial 2
minutes	temperature °C			
0	63	62	55	58
3	56	59	49	56
6	50	53	45	53
9	46	48	42	51
12	41	43	39	49
15	37	38	37	47
18	34	34	35	45
21	31	30	33	43
24	27	26	31	41
27		23		39
28	24		29	
30		20		38
31	21		27	
33		17		36
34	19		25	
36		15		34
37	17		24	
39		12		33
40	14		23	
42		10		31
43	12		21	
45		8		30
47	10		19	
48		6		28

[1]minutes from time meals were placed in freezer

[2]single meal placed directly on freezer shelf

[3]meals stacked three deep on freezer shelf; temperature monitored for center meal

Table 11. (cont.)

time[1]	configuration: single[2] trial 1	single[2] trial 2	stacked[3] trial 1	stacked[3] trial 2
minutes	temperature °C			
51	8	4	18	27
54		3		25
55	6		17	
57	5	2	16	24
60	4	1	15	23
63	3	0	14	21
66	2		13	20
69	1		12	19
72	0		11	18
75			9	17
78			9	16
81				15
82			8	
84			7	14
87			7	13
90			6	12
93			5	11
96			4	10
99			4	9
102			3	8
105				8
106			2	
108			2	7
111			2	6
114			1	5
117			1	5
120			0	4
123				3
126				3
129				2
132				2
135				1
138				1
141				1
144				0

Table 12. Time and temperature relationship of baked chicken frozen single and stacked in an institutional walk-in freezer

time[1]	configuration			
	single[2]		stacked[3]	
	trial 1	trial 2	trial 1	trial 2
minutes	temperature °C			
0	63	56	63	53
3	61	52	62	52
6	58	47	60	48
9	55	43	59	47
12	53	38	57	43
15	50	35	56	41
18	47	31	54	38
21	43	28	51	36
24	40	25	49	34
27	37	23	46	32
30	34	20	44	29
33	31	18	42	28
36	28	16	39	26
39	26	14	37	24
42	23	13	34	23
45	21	11	32	21
48	18	9	30	19
51	17	8	28	18
54	15	6	26	17
57	13	5	24	16
60	11	4	22	15
63	10	3	21	13
66	8	3	18	12
69	8	2	17	11
72	6	2	16	10

[1]minutes from time meals were placed in freezer

[2]single meal placed directly on freezer shelf

[3]meals stacked three deep on freezer shelf; temperature monitored for center meal

Table 12. (cont.)

time[1]	configuration			
	single[2]		stacked[3]	
	trial 1	trial 2	trial 1	trial 2
minutes	temperature °C			
75	4	1	14	9
78	3	0	13	8
81	2		12	8
84	1		11	7
87	1		9	6
90	1		8	6
93	0		7	6
96			6	6
99			5	5
102			5	5
105			4	5
108			3	4
111			3	4
114			2	4
117			1	4
120			1	3
123			0	3
126				3
129				3
132				3
135				3
138				3
141				3
144				2
147				2
150				2
153				2
156				1
159				1
162				0

Table 13. Time and temperature relationship of yankee pot roast frozen single and stacked in a refrigerator/freezer[1]

time[2]	configuration			
	single[3]		stacked[4]	
	trial 1	trial 2	trial 1	trial 2
minutes	temperature °C			
0	46	41	43	46
3	41	34	41	44
6	36	28	39	42
9	32	24	38	39
12	28	20	36	37
15	25	16	35	35
18	22	13	33	32
21	20	10	32	30
24	17	8	30	28
27	15	6	29	26
30	13	4	28	24
33	12	3	26	22
36	10	2	25	21
39	9	1	24	20
42	7	0	23	18
45	6		21	17
48	5		20	16
51	4		19	15
54	3		18	14
57	2		18	13
60	?		17	12
63	1		16	11
66	0		15	11
69			14	10
72			13	9

[1] frozen in freezer section

[2] minutes from time meals were placed in freezer

[3] single meal placed directly on freezer shelf

[4] meals stacked three deep on freezer shelf; temperature monitored for center meal

Table 13. (cont.)

time[2]	configuration			
	single[3]		stacked[4]	
	trial 1	trial 2	trial 1	trial 2
minutes	----------temperature °C----------			
75			13	9
78			12	8
81			11	7
84			10	7
87			10	6
90			9	6
93			9	5
96			8	5
99			7	5
102			7	4
105			6	4
108			6	3
111			5	3
114			5	3
117			4	2
120			4	2
123			4	2
126			3	2
129			3	1
132			2	1
135			2	1
138			2	1
141			1	0
144			1	
147			1	
150			0	

Table 14. Time and temperature relationship of yankee pot roast frozen single and stacked in an upright freezer

	configuration			
	single[2]		stacked[3]	
time[1]	trial 1	trial 2	trial 1	trial 2
minutes	temperature °C			
0	37	37	40	48
3	30	28	39	46
6	26	18	38	43
9	21	11	36	40
12	18	5	34	38
15	15	2	33	35
18	12	0	31	34
21	10		29	31
24	7		27	29
27	6		25	27
30	4		23	25
33	2		22	23
36	1		20	21
39	0		19	20
42			17	18
45			16	17
48			15	15
51			13	14
54			12	12
57			11	11
60			10	10
63			9	9
66			8	7
69			7	6
72			6	5

[1]minutes from time meals were placed in freezer

[2]single meal placed directly on freezer shelf

[3]meals stacked three deep on freezer shelf; temperature monitored for center meal

Table 14. (cont.)

time[1]	configuration			
	single[2]		stacked[3]	
	trial 1	trial 2	trial 1	trial 2
minutes	----------temperature °C----------			
75			5	4
78			4	4
81			3	3
84			3	2
87			2	1
90			1	1
93			1	0
96			0	

Table 15. Time and temperature relationship of yankee pot roast frozen single and stacked in an institutional walk-in freezer

	configuration			
	single[2]		stacked[3]	
time[1]	trial 1	trial 2	trial 1	trial 2
minutes	temperature °C			
0	53	53	47	47
3	49	47	44	45
6	43	41	41	43
9	39	37	39	41
12	34	33	36	39
15	30	28	32	38
18	25	25	29	36
21	22	23	26	34
24	18	20	23	33
27	16	18	21	31
30	13	17	19	29
33	11	15	16	28
36	8	13	14	27
39	7	12	13	26
42	5	11	10	25
45	4	10	9	23
48	3	8	7	22
51	2	7	6	21
54	1	6	4	19
57	0	5	3	18
60		3	2	16
63		3	1	14
66		2	0	13
69		1		11
72		0		9

[1]minutes from time meals were placed in freezer

[2]single meal placed directly on freezer shelf

[3]meals stacked three deep on freezer shelf; temperature monitored for center meal

Table 15. (cont.)

time[1]	configuration			
	single[2]		stacked[3]	
	trial 1	trial 2	trial 1	trial 2
minutes	temperature °C			
75				8
78				6
81				5
84				4
87				3
90				2
93				1
96				0

TIME/TEMPERATURE RELATIONSHIP OF PACKAGED MEALS DURING FREEZING: ELDERLY FEEDING PROGRAMS

by

CHERYL K. THOLE

B.S., Kansas State University, 1981

M.S., Kansas State University, 1982

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Hotel, Restaurant,
Institution Management and Dietetics

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1989

ABSTRACT

This research was conducted to determine time/temperature relationships during freezing of individually packaged meals for elderly feeding programs. Specific objectives were to investigate impact on freezing time of meal arrangement in the freezer and to examine if freezing time was related to freezing equipment.

The temperature of two entrees, oven baked chicken (chicken) and yankee pot roast (pot roast), were recorded during the study. Meals were packaged individually in divided foil containers and covered with a foil-backed cardboard lid. The freezer section of a refrigerator/freezer, a home-size upright, and an institutional walk-in freezer were used. Recording thermocouples were used to obtain the internal temperature of the entrees in the refrigerator/freezer and upright; a Celsius thermometer was used for the temperatures in the walk-in. Meals were placed in the freezers in two configurations: individually or stacked three deep on the freezer shelf, with the thermocouple or thermometer inserted in the center meal. The study was repeated and mean times in the temperature danger zone (7 to 60°C) and to reach 0°C were determined.

Results indicated that both the chicken and pot roast in the stacked configuration remained in the temperature danger zone in all freezers considerably longer than did the same item placed singly. Chicken, stacked in the refrigerator/freezer, remained in the temperature danger zone for longer than the two hour maximum time

recommended for both trials. All other freezers and arrangements of the two types of meals resulted in food being in the danger zone less than two hours.

Results suggest training of employees in elderly feeding programs may be needed on proper handling procedures of food to be frozen. Managers at congregate sites freezing meals should monitor freezer temperatures, maintain freezer temperatures at or below -18°C (0°F), and place meals in a single layer when freezing.