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Scheduling Labor and Equipment in a Cook Chill Food Production System

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To the Graduate Council:

I am submitting herewith a thesis written by Martha Jane Antrobus entitled "Scheduling Labor and Equipment in a Cook Chill Food Production System." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Science and Technology.

Betty L. Beach, Major Professor

We have read this thesis and recommend its acceptance:

Mary Jo Hitchcock, Frances E. Andrews

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a thesis written by Martha Jane Antrobus entitled "Scheduling Labor and Equipment in a Cook Chill Food Production System." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Systems Administration.

Betty L. Beach
Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

SCHEDULING LABOR AND EQUIPMENT IN A COOK CHILL FOOD PRODUCTION SYSTEM

A Thesis
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Degree
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Martha Jane Antrobus

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ABSTRACT

Hospital foodservice productivity is an area where improvement is important, particularly in light of the current emphasis on cost containment in the health care field. In a foodservice system productivity is measured by input/output ratio. Resources are the system's inputs. There is little information on the effect on productivity of variation in quantity of resources and sequencing of operations, the basic aspects of scheduling.

The COST ARREST model was recommended as a tool for management decision-making and productivity monitoring in a foodservice system. The program was used to study the effect of varying labor time and activity sequencing on entree production in a cook chill foodservice system. Results were compared with conventional scheduling.

Data from an existing foodservice operation were used to determine available labor and equipment and to analyze entree production formulas. Formulas were broken down into activities having definite time and resource requirements. Patient entree production for six days was evaluated on the basis of labor cost and labor and equipment time requirements including delays using two levels of labor and different criteria for scheduling priority. The results were compared with conventional scheduling, that which was done intuitively by production personnel.

The production plan, Plan I, using most labor resulted in greatest labor cost and delay. In the plan, scheduling priority was given to items requiring long production time.

Two plans using less labor, plan II giving priority to long preparation time and plan III to short labor requirement, were similar in results as to labor utilization and appeared to be more labor efficient than plan I. Different sequencing did not demonstrate major differences in production duration.

Conventional scheduling was similar to plans II and III in results. It was not compared with plan I because of dissimilarity in labor level. Plan I resulted in shorter duration of oven use and was believed to be more energy efficient than plans II and III. Conventional scheduling resulted in more efficient use of the slicer than COST ARREST plans. The COST ARREST scheduling algorithm provided a useful tool for management decision-making and productivity monitoring in a cook chill food production system.

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CHAPTER I

INTRODUCTION

The need for improved productivity in foodservice has long been recognized (Anonymous, 1973). With the current emphasis on cost containment in the health care industry, hospital foodservice administrators have an obligation for commitment to the aims of the Voluntary Effort to control costs. The Voluntary Effort (VE) was formed in 1977 by the American Hospital Association, American Medical Association, and the Federation of American Hospitals. As the name suggests, the purpose of the coalition was to encourage self-regulation in the health care industry and to demonstrate that cost control could be achieved without further federal government intervention.

In December 1979 the National Steering Committee for the Voluntary Effort published goals and objectives for 1980 and beyond. Among the committee's priorities was the need for substantial improvement in productivity. A number one objective was to keep expenditures at the lowest possible level consistent with quality of care, through a continued effort to improve efficiency and effectiveness, especially in regard to measurement and improvement of labor productivity.

Operational auditing, with emphasis placed on the need for internal productivity monitoring, has been recommended for cost containment. Another need is measuring performance against predetermined, relevant standards (Wolper, 1979). In the health care industry where sophisticated machines and highly trained technicians are taken for granted, the foodservice department has often failed to demonstrate the effect that optimum resource utilization can have on the dietary care product.

Food and menus contain a large number of variable factors. When these are complicated by personnel differences, food preparation activities do not lend themselves to simple calculations. Perhaps because of confusion presented by this array of differences, little has been done on setting food production standards. There has been widespread failure to evaluate the influence of various resources which serve as systems inputs on the output of the food production system.

The cook chill foodservice system using a restaurant menu offers an appropriate framework within which to maximize resource use and control waste while providing the quality to which the health care consumer is entitled and which is expected. The restaurant type menu for hospital use, as the name implies, has characteristics of that used in a restaurant. Most menu items are the same each day and a variety of items is offered. On the familiar cycle menu popular items such as roast beef or baked ham may be offered once or twice a week. On the restaurant menu foods that most customers prefer can be served daily. As in some restaurants, the menu may include daily special items such as a vegetable, entree or dessert "of the day."

When most of the food items offered daily do not vary, accurate forecasting of requirements is possible based on customer or patient count and past usage records. Tallying of menu selections is not necessary to determine amounts to prepare.

In the cook chill foodservice system food is prepared, quickly chilled, and heated only after portioning, at time of service. Normally foods are prepared the day before they are to be used and holding time is 24 hours. A small over-production is acceptable since it results only in an extension in chilled holding time. If an unexpectedly heavy demand for one menu item occurs one day, the same menu item has been prepared or is being prepared for the next day and can be used.

The flexibility afforded to the food production system by the combination of restaurant menu and cook chill system eliminates much of the deadline dilemma and resultant stress of traditional food service. It should permit scheduling of labor and equipment based on optimum resource utilization rather than time limits.

Identification of the Problem

Because the cook chill system using restaurant menu appears so simple to use efficiently and so well suited to the hospital setting, there is danger of overlooking basic control mechanisms. For any system to function properly there must be standards, checks and measures, and corrective action taken when standards are not met.

It is the function of the professional to establish standards. In an operating foodservice system the standard for productivity is ordinarily that amount which strikes a balance between what the quickest and the slowest worker can accomplish. Quality of food is based on standards of flavor, texture, color, nutritional value and microbial safety. Precautions must be taken to avoid increased productivity at the expense of quality. Quality concerns both food and the work environment for the foodservice employee.

Increased productivity could be achieved by increased volume of output or reduced cost of input. Better measurement is one method of identifying areas where input/output ratios can be improved.

Productivity or output per unit of input is affected by available resources. If resources are adequate there is positive effect on productivity. Inadequate or insufficient resources lead to delays, possible quality deterioration and decline in output.

The resources critical to a food production system, labor, materials, equipment, space and energy, are the basis for measurement of productivity in the system. A cost can be assigned to these resources. There is a lack of information on the effect of varying quantity of resources on production.

Scheduling is a decision-making process. The two basic components of scheduling are resources and sequencing. Resources, the inputs of a system, have limits based on amount or capacity. Sequencing constraints are results of product requirements. In food production, typical constraints are serving time deadlines, holding period limits, and essential predecessor activities.

The scheduling algorithm COST ARREST was recommended as a potential tool for management decision-making and productivity monitoring in a cook chill foodservice system. Using input from an actual food production system was recommended as a method to determine additional refinements which could improve the technique for use in an ongoing operation (Lambert, 1979).

Purpose

The purpose of this research was to study the effect of labor time available on the sequencing of entree production activities using the COST ARREST scheduling algorithm. The results of this analysis were compared with conventional scheduling in a cook chill foodservice system.

CHAPTER 2

REVIEW OF LITERATURE

Concern with productivity in foodservice is not new. A survey of studies on work measurement cited one paper on cost and labor hours from 1929 (David, 1978). Foodservice workers spend as little as 47 percent of working hours in productive labor as compared to an 80 to 85 percent desirable level of productivity (Kotschevar, 1974). Productivity can only be evaluated by measurement. Measures of input are usually labor time or labor cost. Output in foodservice is sales or meals produced (David, 1978).

The American Society of Hospital Food Service Administrators in calling for increased productivity in foodservice included the need for implementing industrial engineering concepts to problems of increasing output and decreasing input (Anon., 1973). Hospital foodservice is an area where a great deal of attention has not been paid to cost. This may reflect the fact that the foodservice department in a hospital is not looked upon as a revenue-producing area. The department budget is not large in relation to the total hospital budget (Brehm, 1977). Being labor intensive, the foodservice department is one where improved productivity can have an important impact (Stokes, 1979). Stokes described "the heart of productivity" as putting people where the work is.

Standards Development

Monitoring productivity is essential in developing standards and auditing performance. Because of the difference between operations and the nearly impossible task of identifying variables, standards established in an institution for its activities are most useful in evaluating performance. The recommendation has been made that each foodservice establish its own standards of productivity based on past performance, ideal performance, and the current needs of the system (Brehm, 1977; David, 1978).

A weakness of standards based on a department's historical records is that observations may have been based on different work methods and workers who had more or less speed than another labor force. A standard should be set which about 95 percent of the population can meet or exceed (Buffa, 1973).

Hazard Analysis Critical Control Points

Quantitative standards cannot be the only measure of effectiveness of a foodservice system. Qualitative standards for foodservice include both sensory aspects (flavor, color, texture), nutritive value and microbial safety. Hazard Analysis Critical Control Point (HACCP) models were developed for reducing microbial hazards in quantity food production. Two major areas for insuring safety included time temperature relationship and equipment sanitation

(Bobeng and David, 1979). These are considerations important to resource allocation, influencing allowable delay periods. Significant intervals are those between getting foods from refrigeration and continuing preparation, completing cooking and refrigeration, and cleaning equipment after use.

Resources

In a general management context, there are three universal resources: capital, time and knowledge. It is managers that make resources productive (Drucker, 1980). Resources are the inputs of a system. If equipment, materials and facilities are adequate, productivity depends on skill and motivation of the worker (Mannisto, 1980).

A traditional classification of resources used in foodservice is capital, labor, food, supplies, energy, equipment and space. In comparing costs of various foodservice systems it has been claimed that savings in labor and space costs produced by convenience foods were more than balanced by increased energy and food costs. Over time, inflation affects resources differently. If energy costs increase faster than labor costs, the cost advantage of less labor intensive systems may be lost (Herz and Souder, 1979).

From the standpoint of using resources efficiently, there is an optimal production volume for a specific foodservice. Production time per portion of food item decreases as volume increases except when the system capacity is reached. Stated differently, the optimal production volume for a specific foodservice system is reached as the system operates at near capacity (Ruf and Matthews, 1973; Waldvogel and Ostenso, 1977).

Work Measurement

A common measure of work in foodservice is meals (output) per labor hour (input). In order to determine input or labor time, several methods of measurement are available. One of the simplest and least costly measures is historical or payroll data. While number of hours paid does not indicate efficiency, it points out variations over time (Marion-Cost, 1980).

A second timely, inexpensive method of measuring labor input is estimates by experts. Both personnel who perform jobs and their supervisors may be asked to estimate time requirements for various tasks. There are many factors which may lead to inaccuracy, but this method is effective in pointing up deviations from standard or usual time needs (Marion-Cost, 1980).

Stopwatch time studies, if sufficient samples are taken, are almost certainly the most accurate method for labor time measurement. Work sampling, in which random observations of a task are made, has been found comparable in accuracy to stopwatch studies (Buffa, 1973).

A refined measurement process, standard time data, considers the elements of work that are common to many jobs and the time required to perform them. An activity time is determined by adding times required for the elements making up the activity. One of the early standard time systems, Methods-Time Measurement (MTM), was developed in 1948. Master Standard Data, based on MTM, uses "obtain, place and rotate" as basic elements. Some standard data systems use universal or minute elements of motion while others are comprised of macro elements, standard data for families of jobs (Buffa, 1973; Crossan and Nance, 1972; Kazarian, 1969).

Adaptation of production time data to quantity foodservice resulted in a Master Standard Data Quantity Food Production Code. Use of the data was verified by stopwatch time study and considered valid and reliable (Waldvogel and Ostenso, 1977).

In conducting studies in an actual foodservice operation, the method of labor time measurement that is sufficiently accurate for study purposes, that will not be disruptive to the operation nor threatening to the personnel, and that can be completed in a reasonably short time is the preferred method (Stokes, 1979). Labor time standards for production activity can be compiled from observation, personnel logs and supervisor estimates. Very accurate time estimates can be made informally when a project is properly broken down into the activities that make up the whole. In the executive approach to informally setting time standards two or three people are involved who are experienced in the type of project being planned. An executive approach was described by Kavanaugh et al.(1978) and was the method judged satisfactory by Beach (1974) and Goodwin (1976).

Scheduling

The scheduling task involves determining the order in which jobs are to be performed and the resources to be allocated to them. Decisions may be based on a number of criteria and on constraints which limit possible solutions. The number of interrelated factors in scheduling makes it nearly impossible for the human brain to juggle them all (AICPA, 1973). There are two basic aspects of scheduling problems: the capacity of resources; and, the limitations placed upon sequencing by the nature of the tasks to be scheduled (Baker, 1974).

Network analysis was developed for the construction industry as a graphic method for project scheduling (Kavanaugh et al.,1978). Two techniques which use network analysis, Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) have been adapted to computer programs to facilitate the scheduling process. Although there are many similarities, the two systems differ in that the amount of time needed to complete the activities which comprise a project are assumed known with certainty in CPM, whereas PERT uses times derived from both optimistic, pessimistic and expected project duration.

In diagramming the events necessary to complete a project an activity-on-node (AON) scheme can be used. The network or graph is made up of circles (nodes) which represent activities. Arrows indicate the flow and relationships of jobs. The critical path or way from start to finish of a job is the route, the length of which determines the project duration. Although some activities could be completed earlier, some must be delayed until certain other activities are finished, and these predecessors influence the overall project duration. Other terms used include "early start," the earliest an activity can begin and "early finish," the duration of the activity added to its early start. "Late finish" is the latest acceptable time for completion of an activity and "late start" is late finish minus the time required to perform the activity (Wiest and Levy, 1977).

The Resource Time Algorithm (REST) is a scheduling methodology developed for the construction industry to allocate resources according to availability. Resource Allocation Production Scheduling (RAPS), based on REST was developed for foodservice application. RAPS, a manual procedure, required activity analysis and network construction (Goodwin, 1976). The REST and RAPS algorithms were adapted and combined to develop a Computerized Scheduling Technique - using the Algorithms of Raps and Rest (COST ARREST).

The COST ARREST program is a computerized scheduling model for food production. In COST ARREST, networking is first used to graph activity time and sequence. Each food production formula is analyzed in terms of discrete activities. Constraints are the necessary predecessors of each activity. Criteria used to establish scheduling priorities in COST ARREST were developed from adding late start and late finish times of activities. This had the effect of giving first rank to formulas requiring the longest time for production and/or earliest required completion time (Lambert, 1979).

Another computer scheduling plan for food production was based on eight priority dispatch rules. These were: random scheduling (RAN), first come and first served (FCFS), shortest and longest operation time (SOT and LOT), fewest number and most number of remaining operations (FNRO and MNRO), and least and most remaining process time (LRPT and MRPT). The simulation model evaluated process times and number of operations in the context of a menu item being produced. A discrete process within one preparation formula might compete for resources with an activity in another recipe. Decision rules considered the total menu item production (Guley and Stinson, 1980).

Labor utilization was enhanced using the three rules that gave priority to menu items that were "short" in terms of processing time or number of operations. These were LRPT, FNRO, and SOT. SOT and LRPT were most effective in keeping delay time low in menu item preparation. In evaluating mean completion time for the four menu items produced in a day, SOT was considered a good decision rule because it fell between the extremes of the other rules. SOT appeared to be the most useful rule in overall effectiveness for menu item scheduling when results were evaluated on the basis of labor utilization, mean delay, and mean completion time (Guley and Stinson, 1980).

CHAPTER 3

PROCEDURE

Improvements in productivity in a foodservice system can be made by decreasing inputs and/or increasing outputs. Input-output ratio is expressed as labor hours per meal or as other measureable production units. Improved scheduling by optimal resource allocation has been considered a method of improving productivity. The COST ARREST model was designed for computerized resource allocation in a hypothetical cook freeze foodservice system (Lambert, 1979).

This study applied the model in an existing foodservice system and compared two plans of scheduling following the COST ARREST logic with conventional scheduling. The COST ARREST model was evaluated as a decision-making tool in a cook chill foodservice system.

The Food Production System

A 529-bed general hospital which used a cook chill foodservice system and restaurant style menu was the setting of this study. Located in a large metropolitan area, the six-year-old facility was well-equipped and adequately staffed. Occupancy for 1979-80 was over 90%, compared with an average of 82% for hospitals of comparable size nationwide (AHA, 1980). High occupancy was believed due in part to a desirable suburban location and to full service being offered six and/or seven days a week during much of the year.

Description of the System

In the cook chill system foods were prepared a day before they were to be used and then chilled and held refrigerated until time for portioning on patient trays. Assembled trays were delivered to service kitchens on 13 patient floors and were held refrigerated until meal time. At that time foods were heated in microwave ovens.

Many convenience foods were used. The entrees offered on the regular menu, which were included in the study, were prepared from uncooked, portion cut chops, steaks, chicken, hamburgers, fish and liver; cooked, boneless ham and turkey breast, and uncooked boneless beef rounds. Combination items as stews and casseroles were primarily prepared from cooked, frozen or canned convenience items.

From the menu used for patients on unrestricted or regular diets, four modified menus were developed. These menus were planned to observe restrictions in kilocalories, fiber, sodium and type of fat. The entrees on the modified menus were as similar as possible to the regular menu items and many items were used on several menus. For example, roast beef was included on all menus, ham was excluded from only the sodium restricted menu, and only the seasoning on broiled chicken differed from one menu to another.

The Restaurant Menu

A restaurant style menu was used six days a week, Monday through Saturday. On the restaurant menu the same basic food items were offered each day. There were many items available, including 14 entrees, vegetables and desserts, but little variety from day to day. There was one daily special sandwich, entree, vegetable and dessert.

A sandwich of the day, chef's salad, hamburger and tuna salad were offered only at noon. Fish, liver and beef stew were offered only at the evening meal. A sample menu is shown in Figure 1. The modified menus were also restaurant style.

On Sunday a continental breakfast consisting of dry cereal, juice, sweet roll, milk and coffee was served. The midday meal was brunch, served at 11:30 a.m. Four entrees were available. The Sunday evening meal was served earlier than on other days, at 4:30 p.m. and a bedtime snack was sent on the supper tray. Entree selections for the Sunday evening meal were limited to two choices.

Production Sheet

Production sheets (Figure A-1, Appendix) were prepared for production requirements for one week. The form with expected requirements for each entree daily, Monday through Saturday, was posted in the preparation unit on Sunday. Daily production was constant because of the restaurant menu and uniform occupancy. Production levels were

Lunch

NAME ________________________ ROOM NO.______

Please check items desired

APPETIZERS
- ☐ Cream Soup with Crackers
- ☐ Vegetable Soup with Crackers

ENTREES: Please select only one
- *☐ Entree of the day
- *☐ Sandwich of the day
- ☐ Roast Beef au jus
- ☐ Swiss Steak
- ☐ Turkey, Dressing and Gravy
- ☐ Broiled Chicken
- ☐ Baked Pork Chop with Gravy
- ☐ Ham Slice with Raisin Sauce
- ☐ Hamburger on Bun
- ☐ Chef's Salad with Meat, Egg and Cheese
- ☐ Tuna Fish Salad

VEGETABLES
- *☐ Vegetable of the day
- ☐ Macaroni and Cheese
- ☐ Mashed Potatoes
- ☐ Au Gratin Potatoes
- ☐ Baked Potato
- ☐ Fluffy Rice
- ☐ Candied Yams
- ☐ Green Beans
- ☐ Broccoli
- ☐ Carrots
- ☐ Corn
- ☐ Green Peas
- ☐ Spinach
- ☐ Turnip Greens

SALADS
- ☐ Tossed Salad
- ☐ Coleslaw
- ☐ Sliced Tomatoes
- ☐ Fruit & Cottage Cheese
- ☐ Congealed Fruit Salad
- ☐ Cranberry Salad

BREADS
- ☐ White Bread
- ☐ Wheat Bread
- ☐ Cornbread
- ☐ Hot Roll
- ☐ Rye Bread
- ☐ Margarine

☐ French Dressing ☐ Mayonnaise ☐ 1000 Island

DESSERTS
- *☐ Dessert of the day
- ☐ Fruit Cup
- ☐ Fresh Fruit
- ☐ Pudding
- ☐ Apple Pie
- ☐ Peach Cobbler
- ☐ Lemon Pie
- ☐ Layer Cake
- ☐ Pound Cake
- ☐ Sherbet
- ☐ Jello

ICE CREAM
- ☐ Vanilla
- ☐ Chocolate
- ☐ Strawberry

BEVERAGES
- ☐ Coffee
- ☐ Iced Tea
- ☐ Decaffeinated Coffee
- ☐ Hot Tea

- ☐ Lemon
- ☐ Cream
- ☐ Sugar

MILK:
- ☐ Whole Milk
- ☐ Low-Fat Milk
- ☐ Skim
- ☐ Buttermilk
- ☐ Chocolate

☐ Sugar Substitute

Dinner

NAME ________________________ ROOM NO.______

Please check items desired

APPETIZERS
- ☐ Cream Soup with Crackers
- ☐ Vegetable Soup with Crackers

ENTREES: Please select only one
- *☐ Entree of the day
- ☐ Roast Beef au jus
- ☐ Liver and Onions with Gravy
- ☐ Swiss Steak
- ☐ Beef Stew
- ☐ Turkey, Dressing and Gravy
- ☐ Broiled Chicken
- ☐ Baked Pork Chop with Gravy
- ☐ Ham Slice with Raisin Sauce
- ☐ Baked Fish in Lemon Butter

VEGETABLES
- *☐ Vegetable of the day
- ☐ Macaroni and Cheese
- ☐ Mashed Potatoes
- ☐ Au Gratin Potatoes
- ☐ Baked Potato
- ☐ Fluffy Rice
- ☐ Candied Yams
- ☐ Green Beans
- ☐ Broccoli
- ☐ Carrots
- ☐ Corn
- ☐ Green Peas
- ☐ Spinach
- ☐ Turnip Greens

SALADS
- ☐ Tossed Salad
- ☐ Coleslaw
- ☐ Sliced Tomatoes
- ☐ Fruit & Cottage Cheese
- ☐ Congealed Fruit Salad
- ☐ Cranberry Salad

BREADS
- ☐ White Bread
- ☐ Wheat Bread
- ☐ Cornbread
- ☐ Hot Roll
- ☐ Rye Bread
- ☐ Margarine

☐ French Dressing ☐ Mayonnaise ☐ 1000 Island

DESSERTS
- *☐ Dessert of the day
- ☐ Fruit Cup
- ☐ Fresh Fruit
- ☐ Pudding
- ☐ Apple Pie
- ☐ Peach Cobbler
- ☐ Lemon Pie
- ☐ Layer Cake
- ☐ Pound Cake
- ☐ Sherbet
- ☐ Jello

ICE CREAM
- ☐ Vanilla
- ☐ Chocolate
- ☐ Strawberry

BEVERAGES
- ☐ Coffee
- ☐ Iced Tea
- ☐ Decaffeinated Coffee
- ☐ Hot Tea

- ☐ Lemon
- ☐ Cream
- ☐ Sugar

MILK:
- ☐ Whole Milk
- ☐ Low-Fat Milk
- ☐ Skim
- ☐ Buttermilk
- ☐ Chocolate

☐ Sugar Substitute

* See other side

Figure 1. Restaurant Style Menu Used in the Food-service Operation.

developed from past usage data. Experience showed that when occupancy level remained steady, the required number of servings of a particular entree varied negligibly on a given day of the week from one week to the next.

A seven-day menu cycle was used for persons who did not select from the menu. Items served on this master menu and the foods offered as specials each day accounted for most of the fluctuations in daily requirements. The entree cook checked the refrigerator each afternoon when the evening meal trays had been assembled and recorded the amount of each menu item on hand. "On hand" at 4:00 p.m. theoretically was the following day's needs. The amount listed as "to prepare," determined by the cook from checking the inventory, was the requirement for the day after that, adjusted for any over- or under-production for the next day.

Employee Food Service

Food for the employee cafeteria was prepared in the same area as that for patients. Menu items were produced on the day of service, held and served hot. Many items were the same as those used for patients but the menus were separate. The cafeteria menu included more combination entrees and fewer convenience foods than did the patient menu.

Labor in the System

Cook positions available. Staffing permitted the scheduling of five cooks daily, Monday through Friday. Cook 1, scheduled to come in at 5:00 a.m. prepared breakfast items for patient service, and sausage, bacon and biscuits for the cafeteria. Breakfast items for patients were not prepared a day ahead and chilled as were other food items. This cook was responsible for starting long-cooking items for patient service, such as roast beef. Cafeteria lunch entrees and cornbread were included in the responsibilities.

Cook 2 scheduled 6:00 a.m. to 2:30 p.m., assisted with both cafeteria and patient production as needed. The individual in this position was responsible for special orders for patients and some modified diet production.

Cook 3, whose primary responsibility was patient entree preparation, worked from 8:00 a.m. to 4:30 p.m. This individual helped in cafeteria food preparation and slicing meat for vending machine sandwiches when time permitted.

Cook 4, called the "tray line cook," was responsible for putting chilled food on the patient tray assembly line for lunch and dinner and for backing up the line during assembly. This cook opened and mixed canned soup, opened canned convenience entrees, prepared sauces and gravy, and ground meat as needed for certain diets. Hours for this cook were 8:00 a.m. to 4:30 p.m.

Cook 5 prepared vegetables for both patient and cafeteria service. This cook was not considered available for patient entree production. Vegetable preparation and making homemade soup required all of the cook's time.

Labor skill level. There was one salary classification for food production personnel. A head cook position (Cook 1) existed informally due to length of service but did not command a higher pay scale. There was a seven-step pay scale for each job classification which specified an annual bonus for employees who had reached the top of their salary ranges. Periodic cost-of-living adjustments were made which increased both entry and top pay, and all employees were eligible for these increases. The salary range for cook in November 1980 was $3.53 to $4.87 per hour.

Labor assignment. Employees were scheduled 8.5 hours daily, with a 30-minute unpaid lunch break and 2 paid 15-minute breaks. Employees took breaks as convenient depending on work in progress.

Labor time available. A ten-hour period was available daily for entree production. Cook 1 began cooking roasts at 6:00 a.m. Cook 3 completed other activities by 4:00 p.m. in order to take an inventory of prepared entrees in the regrigerator before going off duty.

By calculating the number of hours each cook position could be assigned to entree production it was determined that 14.5 labor hours daily could be allocated Monday through Saturday. The times when these hours were available was different on Saturday. Fewer personnel were on duty Saturday to reflect a decreased cafeteria work load. Patient requirements were also less on weekends.

No patient entree production was scheduled on Sunday. Production demands for Monday were met with Saturday production and by early production on Monday. The menu was planned to allow for this. Because most new patient admissions were on Sunday and Monday, there were fewer selected menus Monday than on other days. Many patients received the standard entree, a convenience beef stew.

Equipment

Equipment in the system was shared between cafeteria and patient production. Because the cafeteria production had conventional serving time constraints, cafeteria equipment demands had precedence when there was competition for equipment. This occurred infrequently and was not considered a significant factor in the study. Cooks were not required to follow a particular sequence in production for each day, allowing flexibility in making adjustments for equipment availability.

Equipment included six convection ovens which had a capacity of three 18 by 24-inch sheet pans. There were six five-gallon steam-jacketed kettles, two compartment steamers, a tilt-fry kettle, bench type mixer, slicer and chopper.

A grill and deep fryer located in the cafeteria short order unit were available at hours when the unit was closed to customers.

<u>Equipment time available.</u> Equipment was available during the hours when the department was open, 5:00 a.m. to 8:00 p.m. For entree production purposes equipment was designated for allocation during the hours when cook labor was available, 6:00 a.m. to 4:00 p.m.

Time available for entree production was not always the whole day due to operational priorities. For example, the tilt skillet was always allocated to breakfast egg production from 6:00 a.m. to 7:30 a.m. The grill and deep fryer in the cafeteria were not available for entree production when the short order area was open, 6:30 a.m. to 10:00 a.m. daily and 11:00 a.m. to 1:30 p.m. Monday through Friday. During the peak period for cafeteria food production, 7:00 a.m. to 11:30 a.m. three convection ovens were designated as available for entree production. Before 7:00 a.m. and after 11:00 a.m. four were available. All steam-jacketed kettles were allocated to vegetable preparation until noon Monday through Saturday.

The slicer was in heavy demand for entree, cafeteria and vending machine production. Most operations were of short duration. Personnel cooperated well and were willing to yield to priority uses. The slicer was designated for entree production from 8:00 a.m. to noon. It was considered desirable to schedule slicing activities in close sequence to avoid the necessity for repeatedly taking apart and thoroughly cleaning the slicer.

Existing Operational Practices

The executive approach was used to determine labor and equipment utilization and sequencing of operations in the cook chill system. Because of the repetitive nature of the menu, time required for various production activities could be readily observed. Supervisor estimates and observations and employee logs were used to develop average time figures.

The cook 3 who prepared entrees for patient service recorded time and activities for a day. The researcher with the assistance of the cooks observed entree production and recorded activity times for each entree on the Production Activities List (Figure A-2, Appendix). Time estimates were averaged for individual variation in speed and for different batch sizes.

Cook 3 was scheduled to work eight hours, plus an unpaid lunch period. About six hours were spent in patient entree production daily. In addition, the cook 3 cleaned the slicer, took inventory of food on hand and prepared a production sheet for the next day. This cook spent about one hour in other non-entree production activities.

Using the Production Activities List, total minutes for each piece of equipment and total labor minutes for each of the six days, Monday through Saturday, were calculated. The activity analysis separated the tasks in an entree production into steps. Each step or activity required a resource (labor or equipment) and a period of time. If two resources were required simultaneously, two activities occurred. The minimum time allocated to an activity was five minutes, and five minutes was established as one time period. Thus when activities were coded for the computer scheduling project, an entree requiring one hour in the oven used twelve five-minute periods of oven time. An activity requiring less than five minutes was allotted the minimum five-minute period. This was considered sufficiently accurate for study purposes.

Availability of resources, labor and equipment, was designated in five-minute periods, 120 periods daily. These figures were derived by multiplying the 12 time periods per hour by the 10 hours from 6:00 a.m. to 4:00 p.m.

COST ARREST

The model developed by Lambert (1979) provided for allocation of available resources to required activities in a food production system. COST ARREST, being computerized, allowed for scheduling a large number of activities rapidly.

Less flexibility in scheduling was permitted in the actual cook chill system than in the hypothetical cook freeze system. Although Lambert found it feasible to prepare food for Tuesday on Friday, this length of time for chilled holding was thought to be undesirable. Recent studies indicate that a longer chilled holding period than was previously thought safe, from a microbial standpoint, may be acceptable. However, further study on the effect of chilled storage on the sensory qualities of cooked foods is needed (Matthews, 1977).

COST ARREST Input

COST ARREST input consisted of production sheet information, labor and equipment availability, activity criterion values, and activity information. Production sheet data included a listing of entrees to be prepared on a given day. The number of different types of resources and number of time periods available for scheduling was coded for computer input.

There were ordinarily six different resources required for patient entree production, cook, oven, slicer, kettle, fryer and steamer. Time periods as previously described consisted of 120 five-minute intervals from 6:00 a.m. to 4:00 p.m. The total number of activities in all the entrees to be produced on one day was another item of essential production sheet information.

Labor and equipment availability have been described in this chapter. Activity criterion values were derived from network analysis based on the AON procedure. Using data from the Production Activities List a flow diagram was prepared for each entree. On the flow diagram there was a starting point for each entree from which activities within the entree production proceeded in sequence. Each activity was represented by a "node" or circle. Within the node, the activity duration, description, and an identifying number were written. Two numbers above the node indicated the "early start" (ES) and "early complete" (EC) times for the activity. Below the node were "late start" and "late complete" (LS and LC) times.

Figure 2 illustrates a completed Production Activities List for Pork Chops. Figure 3 shows a flow diagram following AON network procedure using data from the pork chops formula.

"Early" times for an activity were determined by calculating the earliest time the entree production could begin and adding the duration of all activities which must precede the given activity. ES plus duration of an activity yielded EC. EC of one activity became ES of the following activity.

Late start and complete times were calculated from the latest completion time for an entree's production. In the cook chill system this was ordinarily the end of the production period, 4:00 p.m. Subtracting the activity duration from late complete time gave its late start value. The late start time of an activity became the late complete

RECIPE NAME Pork Chops DATE 4-7-80

PRODUCTION ACTIVITIES LIST

NUMBER	ACTIVITY	LABOR TYPE	EQUIP-MENT	TASK PRECEDING	TIME IN MIN
1	Grease pans; get	Cook			15
	out chops; dredge				
	in flour, pan.				
2	Brown at 350		Oven	1	30
	degrees				
3	Put in deep pans,	Cook		2	10
	add water, cover.				
4	Bake at 350		Oven	3	30
	degrees				
5	Remove, refrig-	Cook		4	5
	erate				

Figure 2. Completed Production Activities List for Pork Chops Preparation.

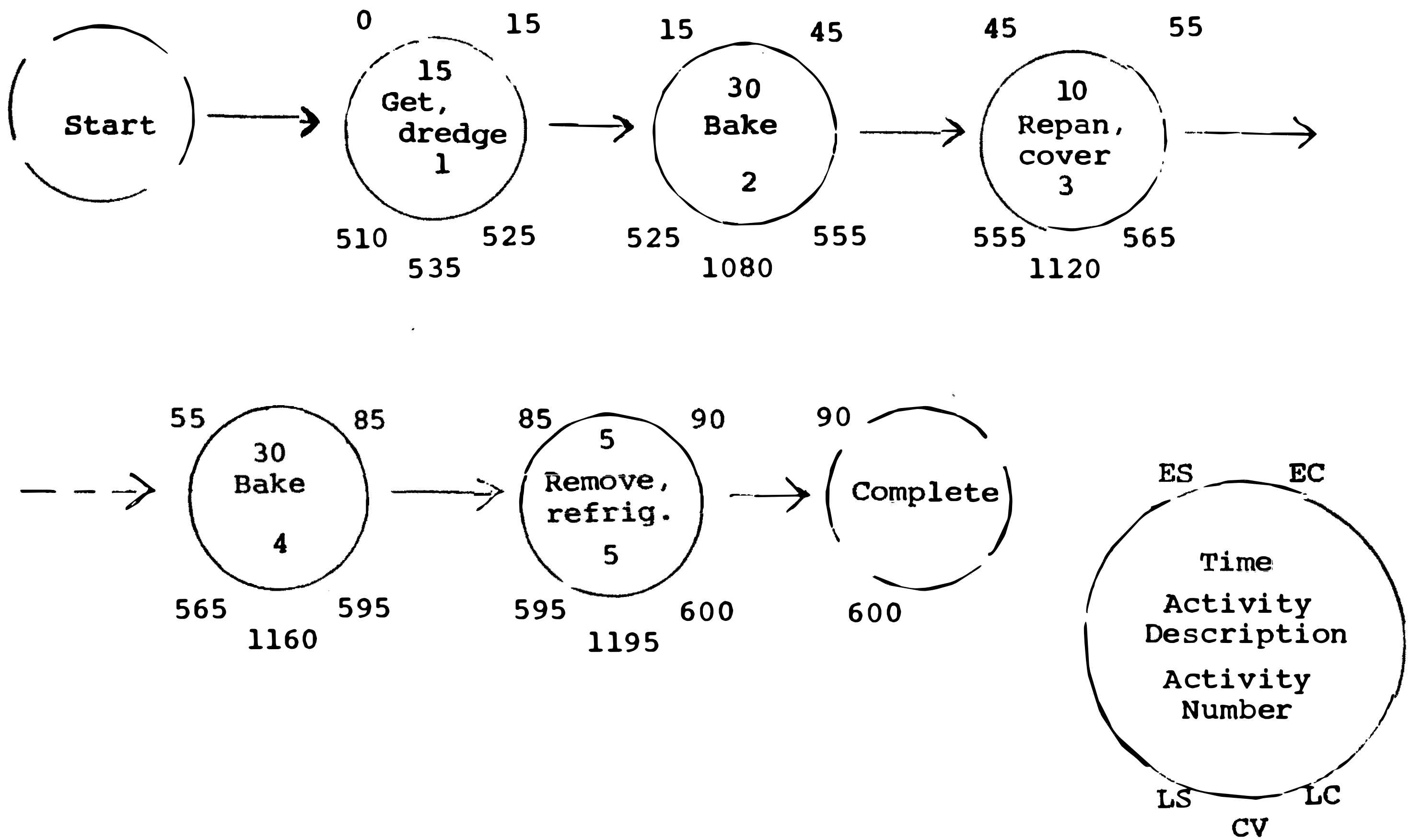

Figure 3. Flow Diagram for Pork Chops Preparation Using AON Network Procedure.

time of its predecessor. Late start and late complete times were added to determine criterion values used for program input. Sequencing of activities by COST ARREST was determined from criterion values. When LS and LC times were used to calculate criterion value, activities having the longest processing periods and/or earliest LC times had lowest values and were given priority over activities having shorter durations and higher numerical values. Activity criterion values within an entree were required to be in ascending numerical order when used as COST ARREST input.

Activity information required for COST ARREST input included resource identification, work content and delay in five-minute periods, resource level and necessary predecessors to the activity. Activities were required to be entered in order of increasing criterion value to coincide with activity criterion value input described above. Specific labor and equipment requirements, work content and predecessors were identified from the network analysis.

Resource level was the number of units of a resource expressed as preferred, efficient, and actual. The Actual Resource Units (ARU) and Efficient Resource Units (ERU) were not necessarily the same, as when two people could do a job more efficiently than one but only one was available. ERU and preferred level were determined by management. Operational constraints, for example the necessity for personnel available to be concentrated in one area at a given time, could influence management to "prefer" less than the efficient resource level for an activity. When fewer or more resource units than the efficient level were assigned to an activity the resulting ratio, ARU/ERU, indicated less than optimal efficiency.

Entree coding. When entrees were coded for input in the COST ARREST program they were given two-digit numbers, in this case from 20 to 39. Activities within entrees were then identified by three-digit numbers, with the first two digits being the number of the entree. For example, entree 24 was pork chops. Activity 241 was the first step in preparing pork chops. This aided in recognizing activities within a particular entree on the computer printout.

Production Schedule Variations

Conventional scheduling. Conventional scheduling was defined as that currently used in the operation. One cook (3) was assigned major responsibility for patient entree production. This individual followed a weekly production schedule which usually remained the same except during holiday periods. The cook determined from one day's closing inventory of prepared entrees what quantity to prepare the following day and recorded this amount on the food production sheet.

Cook 1 put on long-cooking items such as roast beef at 6:00 a.m. Cook 3 sequenced activities as seemed appropriate, intuitively making adjustments for equipment availability. If the amount of an item recorded from the previous day's inventory indicated the need for more of that entree earlier than usual, the cook arranged to prepare it earlier.

The cook 3 was asked to record the time for beginning and completing every activity within each entree for one day, and on other days to record the sequence of activities. Since the production schedule reflected the same menu items each day and similar production quantities, activity times were assumed to be consistent.

Production plan I. The first production plan designed for use in the computer program designated maximum labor available for entree production. Using this plan 14.5 hours of labor time were allocated during the 10-hour production period. This consisted of one cook from 6:00 a.m. to 8:00 a.m., two from 8:00 a.m. to 10:00 a.m., one from 10:00 a.m. to 1:30 p.m. and two from 1:30 p.m. to 4:00 p.m. Lunch and break times were excluded. A chart of labor availability is shown in Figure 4.

Daily production was the same as in conventional scheduling in all production plans. Equipment allocation was the same in all plans, with Saturday differing from other days as described previously.

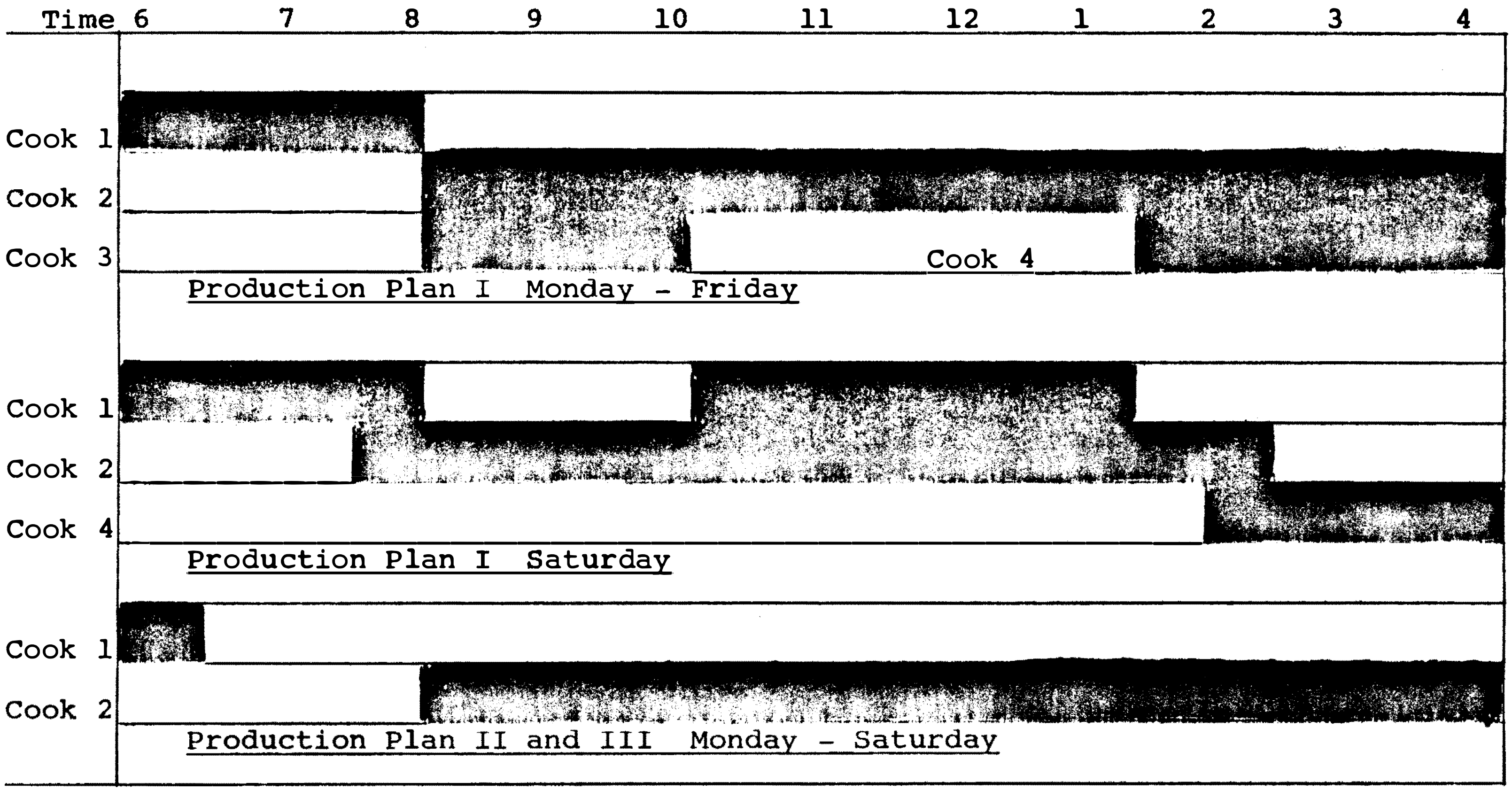

Figure 4. Availability of Cook Labor.

Shaded areas indicate labor allocated for patient entree production.

Criterion values for activities were determined by adding late start and complete times for each activity. This caused the activities requiring the longest preparation times and those needed earliest to be scheduled first.

Production plan II. Plan II designated the same equipment availability and criterion values as plan I and had the same entree production requirements. Labor was varied to closely simulate actual operational practice. One cook was allocated for entree production from 6:00 a.m. to 6:30 a.m. and one from 8:00 a.m. to 4:00 p.m. Total labor time available was 8.5 hours.

Production plan III. In production plan III a modification in scheduling priorities was made so that entrees requiring the least labor time were scheduled first. It was not feasible to do this in the computer program, but the COST ARREST logic was applied to the same input information to develop the production sequence and resource allocation.

Equipment available in plan III was as in the other two plans. Labor was as in plan II, 8.5 hours daily. Entrees as a whole rather than unique activities were arranged in order of increasing amount of labor time required. The Production Activities List and network diagrams were used to calculate labor time for the complete production of each entree.

The effect of this arrangement was to give priority to the reverse of that of the other two plans, allowing entrees requiring the least labor time rather than longest production to be scheduled first. When there was a requirement for an entree earlier than it would be produced using these criteria, an exception was made.

Production Plan Differences

	Plan I	Plan II	Plan III
Labor hours	14.5	8.5	8.5
Sequencing priority	Early need Long production	Early need Long production	Early need Short labor time

COST ARREST Output

COST ARREST output consisted of daily production sheets. These included a list of entrees scheduled for production and a list of activity numbers arranged by criterion value.

After arranging activities in criterion value order the scheduling process determined when predecessor activities were complete and resources available for assigning the next activity. It required that sufficient quantity of the resource be available to complete the activity, as no delay was permitted. The program allocated the preferred resource level if available.

Computer output represented blocks of time, each block 2.5 hours by five-minute periods. At the top of each time block resources available during that time period were identified numerically. Beneath each availability number was a corresponding number indicating how many of the available units of the resource had been allocated during that time period.

The left side of the printout, below the resource allocation information, listed the activity numbers in criterion value order. The resource required by each activity was printed to the right of the activity number. The time periods during which each activity was scheduled and the number of resource units assigned to it could be identified by examining the remaining right section of the printout. An example of the computer printout is shown in Figure 5.

Output adjustment criteria. When the computer program allocated resources, it was possible to generate schedules that were unacceptable. If schedules did not meet three pre-established criteria, manual adjustments were made. The criteria were:

1. A "get out" activity must be followed by further processing within 15 minutes. For example, meat could not be left standing to await oven availability. This happened when labor was available and equipment was at capacity.
2. A "put away" activity must not be delayed more than 15 minutes after completion of processing.

```
CODE     RESOURCES AVAILABLE/ ALLOCATED
  1        4   4   4   4   4   4   4   4   4   4   4   4   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
  1        0   1   2   2   2   3   3   3   3   3   4   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3

  2        0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   1   1   1   1   1
  2        0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   1   1   1   1   1

 10        1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   2   2   2   2   2   2
 10        1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   2   2   2   2   2   2

  4        0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
  4        0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

  5        0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
  5        0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

NUM WCT  ALLOCATIONS/5 MIN PERIODS. EACH BLOCK = 2 1/2  HOURS
201  10    1 *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
202   1  ***   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
231  10  ***   1 *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
241  10  *** ***   1   1   1 *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
291  10  *** *** *** *** ***   1   1   1   1   1 *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
242   1  *** *** *** *** ***   1   1   1   1   1   1 *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
232   1  *** ***   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1 *** *** *** *** *** *** *** *** *** ***
261  10  *** *** *** *** *** *** *** *** *** ***   1   1 *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
243  10  *** *** *** *** *** *** *** *** *** *** *** ***   1   1 *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
292   1  *** *** *** *** *** *** *** *** *** ***   1   1   1   1   1   1   1   1   1   1   1   1 *** *** *** *** *** *** *** ***
211  10  *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1 *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
351  10  *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1 *** *** *** *** *** *** *** *** *** *** *** *** *** ***
352   5  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
262   1  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1   1   1   1 *** *** *** *** *** ***
353   5  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
281  10  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1 *** *** *** *** *** *** *** *** *** *** *** *** ***
301  10  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1 *** *** *** *** *** *** *** *** *** *** *** ***
354  10  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1 *** *** *** *** *** *** *** *** *** *** ***
220  10  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1 *** *** *** *** *** *** *** *** *** ***
251  10  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1 *** *** *** *** *** *** *** *** ***
263  10  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1 *** *** *** *** *** *** *** ***
283  10  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1 *** *** *** *** *** *** ***
311  10  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1 *** *** *** *** *** ***
212   2  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1   1   1   1   1   1
213  10  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1   1   1   1   1   1
244   1  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1   1   1   1   1   1 *** ***
355   5  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
282   1  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1   1 *** *** *** ***
284   1  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1   1 *** ***
293  10  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1   1 *** *** *** ***
302   1  *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***   1   1
```

Figure 5 Example of Computer Printout for COST ARREST Program.

Because each activity was scheduled without interruption, an item might finish roasting, requiring oven only, and labor not be assigned to remove and put it away for hours.

3. Activities requiring two resources, usually man and machine, simultaneously must be scheduled at the same time. Because machines and labor were separate resources, an activity requiring both had to be coded as two activities. When these two were not scheduled simultaneously, manual adjustment was made.

These manual adjustments were made in the order in which the activities occurred. This could necessitate that succeeding activities be delayed or scheduled earlier to replace activities that did not meet criteria for scheduling.

Summarizing output. Information from the computer printout was transferred to a log so that adjustments could be made before data were tabulated. Activities taken from the printout were logged in groups so that activities within an entree could be examined in relation to each other. Information was then graphed so labor and equipment could be evaluated together. This made it apparent when and where adjustments in scheduling were required.

Delay

All Production Activities Lists were prepared as start to finish operations with no allowance for delay. The COST ARREST program did not permit scheduling interruptions within an activity. The program did allow activity scheduling without regard to the entree as a whole. The adjustments required due to this were based on output adjustment criteria which have been explained.

Any time period on a given day that was not scheduled from the time a resource was designated available for allocation until the last activity requiring that resource was scheduled was called delay. Delay was classified as either forced delay or alternative productive time.

Forced delay (FD). After output was summarized delay periods were identified for both labor and equipment. FD was defined as an interval of 15 minutes or less when a resource was not allocated for productive activity.

Alternative productive time (APT). Delay periods of longer than 15 minutes were designated as APT. The assumption was made that either labor or equipment that was unscheduled for more than 15 minutes could be put to productive use in another capacity. The time when a resource was available before it was first used was included in delay, frequently as APT. After the last activity for which a resource was used in a day was completed, although the resource had been designated as available, no delay was attributed to it.

Duration

The length of time from when a resource was first made available for entree production until the last activity for which it was used was finished was the duration of that resource's use for that day. When there was more than one unit of a resource, such as ovens, the sum of the durations of all units was used for duration for that day.

Labor Cost

Labor cost was calculated for the three plans for each day and for one week. Cost was computed for hours required for production plus forced delay periods. This was done by multiplying the labor duration for each day, minus alternative productive time, by the average hourly rate for the cook position.

Analysis of Data

Sequencing of entree production activities under three production plans was compared with that in a conventional scheduling method. Labor and equipment demands including duration and forced delay were compared for the two computer-generated and one manually calculated plan. Labor cost including forced delay was determined for the three plans.

CHAPTER 4

RESULTS AND DISCUSSION

A computer model designed for resource allocation in a hypothetical cook freeze food production system was applied in an existing cook chill foodservice system. Labor and equipment utilization in the cook chill foodservice system was determined for six days using three production scheduling plans. The plans incorporated two different levels of labor availability and two scheduling priorities. The effects on resource requirements and labor cost were compared. Sequencing of entree production activities in the system by conventional scheduling was recorded for comparison with that done in the resource allocation model. Output from the COST ARREST program was used to analyze labor and equipment requirements and delay periods and to determine labor cost under three food production plans.

Results of the COST ARREST Program

Resource Time Requirements

Resource time requirements were based on the Production Activities List prepared for each entree. No delay, forced or alternative productive, was included in these requirements. The time requirements for each kind of equipment and for labor were totalled for each day and the week's total for each resource determined. Production requirements for each day, Monday through Saturday, remained constant in the three production plans. Resource requirements in minutes by category are shown in Table 1.

An example of the production schedules for each day of the week appears in Figure 6. The total number of activities in all the entrees produced on a given day is included.

Labor Requirements

Average daily labor time required for the week was 4.7 hours. Range of labor requirement was from 3.25 hours to 5.8 hours. On Wednesday the least amount of labor was required. Labor demand on Wednesday was 56 percent of that for Saturday, which had the greatest labor requirement. Wednesday labor time was 69 percent of the average daily requirement.

Low labor requirement on Wednesday was partly due to the fact that the luncheon entree for persons on regular diets who had not selected from the menu was tuna salad. This was prepared in the salad area and not by cook 3. The "entree of the day" for Thursday was a canned convenience item, chicken and dumplings, which did not require preparation on Wednesday. High labor requirement on Saturday and Monday, which had the second highest demand for labor, was influenced by the six-day plan with no scheduled entree production on Sunday.

TABLE 1

Labor and Equipment Requirements in Minutes for Six-Day Production in a Cook Chill Foodservice System

Day	Cook	Convection Oven	Slicer	Fryer	5-Gallon Kettle	Steamer
Monday	325	740	95	-	-	-
Tuesday	270	660	60	-	35	-
Wednesday	195	590	60	-	-	-
Thursday	255	750	45	-	-	-
Friday	290	610	75	50	-	-
Saturday	350	510	50	100	15	10
Total	1685	3860	385	150	50	10
Range	195-350	510-750	45-95	0-150	0-50	0-10

MONDAY (48)	TUESDAY (53)	WEDNESDAY (37)	THURSDAY (44)	FRIDAY (53)	SATURDAY (36)
Beef Round (uncooked)	Beef Round	Beef Round	Beef Round	Beef Round	Beef Round
Turkey	Turkey	Turkey	Turkey	Turkey	Turkey
Ham	Ham	Ham	Ham	Ham	Ham
Roast Beef (cooked)	Roast Beef	Roast Beef	Roast Beef	Roast Beef	Roast Beef
Brl. Chicken	Brl. Chicken	-	Brl. Chicken	-	Brl. Chicken
Pork Chops	Pork Chops	Pork Chops	Pork Chops	Pork Chops	Canadian Bacon
Liver/onions	Liver/onions	Liver/onions	Liver/onions	Liver/onions	Fried Chicken
Fish	Fish	Fish	Fish	Fish	Eggs Benedict
Hamburger	Hamburger	Hamburger	Hamburger	Hamburger	Chopped Steak
Swiss Steak	Swiss Steak	Swiss Steak	Swiss Steak	Swiss Steak	
Brl. Steak	Brl. Steak	Brl. Steak	Brl. Steak	Brl. Steak	
Meat Loaf	Spaghetti & Meat Sauce		Pork Loin (uncooked)	Roast Pork (cooked)	
Beef Stew			Chicken & Dumplings	Shrimp	
Creamed Chicken					

Figure 6. Daily Production Schedules.

Numbers in parentheses are numbers of activities in entrees scheduled for the day.

Duration of Production

Production duration for labor was the time that elapsed from the time when a cook was designated as available for entree production until completion of the last activity for that person for the day. When several cooks were available, the figure used was the sum of their labor time durations. Duration of labor time for each production plan is shown in Table 2.

Production plan I. Production plan I allocated 14.5 hours of labor time daily to entree production. This was considered the maximum labor time that could be made available in the food production system. Average duration was 7.5 hours with a range of 1.33 hours from shortest to longest duration under this plan. Scheduling priority was given to items requiring long processing time.

Production plan II. Plan II allocated 8.5 hours labor daily to entree production. Average daily duration of production was 5.6 hours. There was a range of 2.25 hours from lowest to highest duration. Long processing activities had scheduling priority.

Production plan III. Plan III gave scheduling priority to activities using least labor time. Average duration under this plan was 5.4 hours. There was a difference of approximately 1.8 hours between shortest and longest duration. Labor availability was 8.5 hours.

TABLE 2

Actual Production Duration in Minutes for Cook Labor in a Cook Chill Foodservice System

Plan	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Total
Plan I	490	455	425	440	470	410	2690
Plan II	355	310	265	400	315	355	2000
Plan III	390	310	280	300	310	365	1955
Range	390-490	310-455	265-425	300-440	310-470	355-410	1955-2690

Summary of production duration. Production plan I required longer production duration than either of the other two plans on every day. The longest daily labor durations under plan II (Thursday, 6.67 hours) and plan III (Monday, 6.5 hours) were less than the shortest in plan I (Saturday, 6.8 hours). When fewer labor hours and cooks were available for production activities scheduling, a decrease in average daily production duration resulted. Average daily production duration was two hours longer in plan I than in plan III, 1.9 hours longer in plan I than plan II.

Labor requirements were least for Wednesday's production. Under plan I scheduling Wednesday production resulted in average production duration .25 hours longer than on Saturday which had highest demand for labor. Activities on Saturday required 2.6 hours more labor time than Wednesday production. Wednesday's long duration was caused by long cooking roast beef which required removal from the oven several hours after other entree production activities were completed. While duration of labor time above requirement is not necessarily an indication of inefficiency, it is a factor which management must recognize to insure that productive activity is planned for slack time.

Plan I range of daily production duration was 80 minutes. This was 55 minutes less than plan II and 30 minutes less than plan III. This was believed due to the fact that removing roast beef was normally the last activity of the day, requiring one labor resource to be available until it was completed. Small differences in the times when cooks completed other activities accounted for variations in daily duration.

From the standpoint of production duration, plans II and III appeared to be more efficient than plan I which made maximum labor available. Available labor was the same for the two plans, 8.5 hours daily. Sequencing priority was based on longest processing time or early need in plan II, shortest labor time required in plan III.

Results agreed with conclusions reached by Lambert (1979) using the COST ARREST program. Lambert reported that utilization of four instead of three cooks did not increase percentage of utilization of labor, but that duration of production remained the same and delay increased.

Weekly total production duration in plan II was longer than in plan III by only 45 minutes although there were three days, Monday, Wednesday and Saturday which under plan II had shorter duration. Plans II and III varied only 8 minutes in average daily duration. On Thursday plan III had 100 minutes less duration than plan II. This was a result of scheduling precedence being given to activities with short labor time in plan III, which permitted two long-cooking items to be placed in the oven early. An item needed early took priority under plan II.

Forced Delay and Alternative Productive Time

Table 3 summarizes forced delay (FD) and alternative productive time (APT). FD was considered to be time intervals of 15 minutes or less when no production activity was scheduled. Total FD for all labor for each day and each plan was calculated. The delay as a percentage of production duration was also recorded.

APT was also delay. Because there are many useful activities that can be performed in a foodservice system in periods of 15 minutes or more these intervals were considered productive delays and were calculated separately from FD. APT for each day and each plan, and as a percentage of production duration was determined.

Production plan I. In production plan I, average daily forced delay was 28 minutes with a range of 15 minutes on Wednesday to 55 minutes on Friday. Average daily APT in the plan was 140 minutes. Under this plan one cook was available from 6:00 a.m. to 8:00 a.m. and priority was given to items requiring long preparation time and/or early need. As a result ovens were filled with long-cooking items in the early production periods. The slicer was unavailable for entree production before 8:00 a.m. With ovens filled, there might be no other activities for cook 1 to perform. Since 8:00 a.m. was the end of that individual's allocation to entree production and he/she would not be assigned to a later activity in that production category, no delay occurred. As previously defined

TABLE 3

Forced Delay (FD) and Alternative Productive Time (APT) for Cook Labor as a Function of Actual Production Duration in a Cook Chill Foodservice System

Production Plan	Monday Min.	Monday %	Tuesday Min.	Tuesday %	Wednesday Min.	Wednesday %	Thursday Min.	Thursday %	Friday Min.	Friday %	Saturday Min.	Saturday %	Average Min.	Average %	Range Min.
Plan I															
FD	20	4	25	5	15	4	30	7	55	12	20	5	28	6	15-55
APT	145	30	160	35	215	51	155	35	125	27	40	10	140	31	40-215
Plan II															
FD	5	1	20	6	45	17	10	3	25	8	5	1	18	6	5-45
APT	25	7	20	6	25	9	135	34	0	-	0	-	34	9	0-135
Plan III															
FD	5	1	40	13	10	4	15	5	20	6	15	4	17	6	5-40
APT	60	15	0	-	75	27	30	10	0	-	0	-	28	9	0-75

delay (FD or APT) occurred only before the last activity for which a resource was scheduled in a day.

Since two cooks were scheduled from 8:00 a.m. to 10:00 a.m. most activities were completed early in the day using plan I. There was then a long APT until long-cooking roast beef could be removed from the oven. Roast beef was produced every day.

On Tuesday a long delay occurred because a kettle was required for production and was not available until noon. Other activities scheduled for Tuesday, except those requiring the kettle and removal of roast beef from the ovens were completed by 9:15 a.m. Wednesday had the longest delay because it had the fewest required production minutes, but again roast beef had to be removed from the oven before all activities were complete.

Labor hours available on Saturday in plan I were the same as other days, 14.5 hours, but were available at different times due to week end scheduling. This may have accounted for less APT on Saturday than on other days.

Production plan II. Production plan II had a range of 5 to 45 minutes forced delay. Longest FD occurred on Wednesday, the day on which required production time was least. On two days, Friday and Saturday, there was no APT. Production on Friday and Saturday required that the cook use the deep fryer which was available for entree production after 10:00 a.m. This was about the time when

APT occurred on other days and at least partially accounts for efficient scheduling. Highest APT, 135 minutes, occurred on Thursday. There was an entree required early on Thursday which took priority over starting roasts at 6:00 a.m. for Cook 1. Roasts were not put into the oven until 8:05 a.m. so there was a period of over two hours from the time when other activities were finished until roasts could be removed from the oven.

Production plan III. Production plan III had FD ranging from 5 to 40 minutes. Longest APT was 75 minutes. This occurred on Wednesday when labor requirement was least. On Monday there was 60 minutes APT. The preparation of pork chops which required the most labor time on that day was the last entree scheduled. There were no other activities available for the cook to perform while the pork chops were cooking. As in plan II, there was no APT on Friday or Saturday. In addition, in plan III APT was zero on Tuesday. Tuesday and Friday each had 53 activities to be scheduled, the most of any day, and about average labor requirements. Since plan III scheduled activities with least labor demand first, results seem to support this scheduling criterion.

Summary of forced delay and alternative productive time. All production plans had the same average percentage, 6 percent forced delay. An average of from 17 to 28 minutes of daily forced delay in the 3 plans occurred.

Plan III had the least average forced delay and APT, with plan II only slightly longer.

Advantageous scheduling, from the standpoint of labor utilization and minimizing delay, as a result of priority being given to menu items requiring short operation time was reported by Guley and Stinson (1980). While differences in the research make it impossible for an exact parallel to be drawn, the short labor time priority as in plan III also appears to enhance labor utilization and reduce delay.

Saturday's production was noticeably low in both types of delay for the three plans. Saturday had the week's highest labor requirement and production activities utilized five different kinds of equipment. Decreased delay on Saturday might indicate a positive effect on scheduling of having a variety of resources to be allocated. Saturday had fewest activities (36) to schedule, which suggests that fewer activities requiring longer periods of labor time contribute to efficient scheduling. Since no interruption was permitted during an activity, no delay could occur.

Labor Cost

Cost of labor for each day for each plan, for six days and daily average was calculated by multiplying hours required plus forced delay by average rate per hour. This was considered direct labor cost. The rate used was $4.12

per hour excluding fringe benefits. Labor cost appears in Table 4. Labor cost was also calculated on the basis of production duration for each day of each plan (Table 5). Computed on that basis, labor cost includes both forced delay and alternative productive time.

Plan I. Weekly direct labor cost for patient entrees in plan I was $127.04. Cost calculated for duration of labor was $184.69 for the week. Direct labor cost was least on Wednesday, when there was least requirement, and highest on Saturday when requirement was greatest. Cost of labor based on duration of production was lowest on Saturday, highest on Monday. Actual requirement for labor was highest on Saturday, second highest on Monday.

Plan II. Weekly direct labor cost in plan II was $123.26. As in plan I, direct cost reflected actual requirement and was highest on Saturday, lowest on Wednesday. Cost of production duration, $137.34 for the week, was also lowest on Wednesday. Greatest daily cost, $27.47, was on Thursday. Thursday plan II had 135 minutes APT (34% of duration). As explained in the analysis of delay, this was a direct result of activity sequencing.

Plan III. Plan III had direct labor cost of $122.91 for the week, with lowest cost on Wednesday, highest on Saturday. Duration of production resulted in a labor cost of $134.25 for the week, lowest on Wednesday, greatest on Monday. Monday's requirement for labor time was the week's

TABLE 4

Direct Cost for Cook Labor in a Cook Chill Foodservice System

Plan	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Total
Plan I	$23.69	$20.26	$14.42	$19.57	$23.69	$25.41	$127.04
Plan II	22.66	19.91	16.48	18.20	21.63	24.38	123.26
Plan III	22.66	21.29	14.07	18.54	21.29	25.06	122.91
Average	23.00	20.49	14.99	18.77	22.20	24.95	124.40

TABLE 5

Cost for Cook Labor Based on Production Duration in a Cook Chill Foodservice System

Plan	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Total
Plan I	$33.64	$31.24	$29.18	$30.21	$32.27	$28.15	$184.69
Plan II	24.37	21.29	18.20	27.47	21.63	24.38	137.34
Plan III	26.78	21.29	19.23	20.60	21.29	25.06	134.25
Average	28.26	24.61	22.20	26.09	25.06	25.86	152.09

second highest. High duration labor cost is a function of labor requirement plus total delay.

Summary of labor cost. Plan I had the highest direct and duration labor cost with plan III slightly lower than plan II. The weekly direct labor cost difference between plans I and III was $4.13 or a 3 percent decrease when scheduling under plan III.

When cost was computed on production duration, plan I was $47.35 higher than Plan II, $50.44 higher than plan III. The percentage difference between plan I and plan II; and, plan I and plan III for duration of labor was 26 and 27 percent, respectively. There was little difference between plans II and III. When labor availability is near requirement as in plans II and III, labor cost as production duration is a more accurate reflection of production requirements than when excess labor is available.

The concept of direct labor cost as excluding APT is dependent upon a flexible labor force and job descriptions which are not unduly restrictive. Particularly in some unionized food production systems this idea would need to be carefully scrutinized to determine if it is a realistic concept.

Oven Requirements

Oven requirements for entree production are shown in Table 1 (page 43). Average daily requirement was 10.7

hours. Production duration was calculated for ovens (Table 6) and forced delay and alternative productive time were evaluated. Forced delay for ovens was unscheduled intervals of 15 minutes or less. Alternative productive time for ovens was defined as for labor, intervals of more than 15 minutes from time of availability until the completion of the last activity for which an oven was used on a given day. FD and APT for each day under each plan and as a function of oven duration are shown in Table 7.

The foodservice operation had six convection ovens. Four of these were designated available for patient entree production except from 7:00 a.m. to 11:00 a.m. when one oven was reassigned to cafeteria use. During the 10-hour production period there were 36 hours of oven time available for allocation to entree production. Maximum requirement for any day was 12.5 hours, exclusive of delay.

Production Duration, Forced Delay and Alternative Productive Time

Plan I. Plan I required a daily convection oven production duration of from 9.9 hours on Saturday to 16 hours on Monday. Duration ran parallel to the order of requirement on all but two days, when longest duration occurred on Monday, the day that had second-longest requirement and second-longest duration on Thursday, the day with longest requirement. On these days there was a 10-minute difference between requirements and a 70-minute difference

TABLE 6

Actual Production Duration in Minutes for Convection Ovens and Slicer in a Cook Chill Foodservice System

Item/Plan	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Total
Convection Ovens							
Plan I	960	750	680	890	735	595	4610
Plan II	1300	1055	1015	1180	1015	1030	6595
Plan III	960	1020	855	1135	900	1045	5915
Range	960-1300	750-1055	680-1015	890-1180	735-1015	595-1045	4610-6595
Slicer							
Plan I	135	70	65	110	95	95	570
Plan II	225	230	180	85	220	145	1085
Plan III	230	200	150	160	220	195	1155
Range	135-230	70-230	65-180	85-160	95-220	95-195	570-1155

TABLE 7

Forced Delay (FD) and Alternative Productive Time (APT) for Convection Ovens as a Function of Actual Production Duration in a Cook Chill Foodservice System

Production Plan	Monday Min.	%	Tuesday Min.	%	Wednesday Min.	%	Thursday Min.	%	Friday Min.	%	Saturday Min.	%
Plan I												
FD	30	3	30	4	35	5	20	2	15	2	5	1
APT	190	20	60	8	55	8	120	13	110	15	80	13
Plan II												
FD	15	1	20	2	35	3	10	1	35	3	0	–
APT	545	42	375	36	390	38	420	36	370	36	520	50
Plan III												
FD	15	2	40	4	30	4	40	4	30	3	5	–
APT	205	21	320	31	235	27	345	30	260	29	530	51

between durations. Range of production duration exhibited a difference of 6.1 hours from lowest to highest requirement.

Difference in range of actual daily requirement time was four hours. Total weekly oven requirement of 64.5 hours represented 84 percent of production duration in plan I. Forced delay ranged from 5 to 35 minutes under plan I, representing from 1 to 5 percent of actual production duration. APT ranged from 55 to 190 minutes or 8 to 20 percent of duration.

Production duration began when a resource was designated as available, which in the case of ovens was 6:00 a.m. On both Monday and Thursday under plan I there was a menu item needed early which had lowest criterion value and therefore highest priority for scheduling. When the cook did not put anything into ovens until this entree was completed a higher than usual APT and production duration for ovens resulted.

Plan II. Plan II production duration for convection ovens ranged from 16.9 hours on Wednesday and Friday to 21.7 hours on Monday, a variation of 4.75 hours. Total requirement for the week was 58 percent of duration. Although forced delay for plan II ranged from none on Saturday to 35 minutes on Wednesday and Friday, a maximum of 3 percent of duration, alternative productive time averaged 40 percent. While criterion values in plan II could have permitted more efficient oven loading and consequently less APT, constraints imposed on the program by the researcher and described in Chapter 3 required that personnel be available to continue processing an entree no longer than 15 minutes after cooking was completed. Under plan II there was no labor available for patient entree production from 6:30 a.m. until 8:00 a.m. when the second cook began work.

Plan III. Production duration of oven use was 98.6 hours for the week under plan III. Daily duration ranged from 14.25 to 18.9 hours, a difference of 4.7 hours. Requirements accounted for 65 percent of duration. Alternative productive time was lower than under plan II on every day except Saturday (when it was 10 minutes longer). This would indicate a sequencing advantage for ovens, when labor is limited, of the criteria for plan III, least labor time requirement. The week's forced delay was 3 percent of production duration as compared with 2 percent in plan II. APT for the week under plan III was 32 percent, under plan II 40 percent, of the weekly duration.

Summary. Of the three production plans, plan I required least production duration for ovens. Under this plan more labor was available early to begin baking and roasting activities. Plan I had the lowest total delay among the three plans, 16 percent, again indicating a favorable result from early labor availability.

Plan II required greatest duration. While plan I and plan II gave priority to items having long overall production time, plan III gave scheduling priority to entrees with short labor requirements. Sometimes the effect on oven use was similar. For example, roast beef was begun early most days in plan I because it had a long cooking requirement. It was begun early in plan III because it had a short labor requirement, merely "put on" and "remove from oven."

Production plan I averaged 5.5 hours less oven use daily than plan III and 3.6 hours less than plan II. Forced delay averaged 3 percent or less in all plans. While it is beyond the scope of this research to determine energy efficiency, the cost of maintaining an empty oven at a given temperature during delay periods is worthy of consideration. With rising energy costs, trade-offs between labor and equipment can become increasingly cost-significant.

Other Resource Requirements

Slicer

The slicer was required from 45 to 95 minutes daily. It was available under all three plans from 8:00 a.m. until noon. Daily average duration was 95 minutes under plan I, 181 minutes under plan II, and 193 minutes under plan III. Plan I in which two cooks were available at 8:00 a.m. scheduled slicer use in approximately half the time of the other two plans. There was little difference in slicer usage in plans II and III. In those plans only one cook was available when the slicer was available for patient entree production, from 8:00 a.m. to noon. Actual production duration in minutes for the slicer under the three plans appears in Table 6, page 59.

From a cost standpoint there is little significance to whether or not a slicer is idle. There must be concern however from the standpoint of microbiological conditions. A hazard may exist if the slicer is not cleaned shortly after use. Additional labor time and cost are incurred if repeated cleaning during the day is required due to intermittent use.

Other Equipment

The deep fat fryer was used in entree production on only two of the six days, Friday and Saturday. The steam-jacketed kettle was used on Tuesday and Saturday, and the compartment steamer on Saturday. Because demand for them was low, these resources did not have a major influence on entree production sequencing. Availability of the fryer was particularly limited and the menu was planned to avoid unnecessary competition for resources.

Sequencing of Activities

Conventional sequencing, that done intuitively by the cook, was compared with sequencing in plans II and III. Plan I could not be meaningfully compared because two cook positions were available at the same time during several hours.

In the plans compared, cooking of roast beef was begun first as it was in conventional sequencing, except on Thursday, Plan II. Under this plan initial preparation of chicken and dumplings, a convenience entree, was begun at 6 a.m. by the cook. This delayed the start of roasting of beef until 8:00 a.m., resulting in delay later in the day. Under plan III preparation of items needed early were not moved forward in sequencing unless failure to do so would result in the items not being prepared by the time they were required for service.

The cook usually prepared swiss steak second, as was done under plans II and III. This frozen convenience entree required 90 minutes in the oven. Relatively long processing time gave the entree early priority in plan II. Minimal labor requirement caused it to have priority in plan III.

On most days under conventional sequencing all slicing was scheduled next. In the computer plans, slicing was scheduled at intervals depending upon quantity of food items needed and resulting length of slicing time and criterion values.

In conventional scheduling broiled chicken, a long-cooking item, was usually one of the last items prepared. As it required relatively long labor time, it also was scheduled late in plan III. The reason for the cook's scheduling this item last was probably because there was less activity around the sink and cook's table after most cafeteria production had been completed. Also, this item was often scheduled to be placed in the oven while the cook took lunch break.

In recording sequencing of activities the cook included other tasks not related to entree production. There was evidence that for that individual there was justification for considering most delay periods productive.

<u>Summary.</u> For daily operational scheduling an intuitive, conventional approach appeared equal in efficiency to a computer generated model using fixed criteria. Slicer use was more efficient in the conventional work sequence. Efficient conventional scheduling is dependent upon knowledgeable, flexible, dependable labor, and cannot be presumed to exist in every situation.

CHAPTER 5

CONCLUSIONS, RECOMMENDATIONS AND SUMMARY

The COST ARREST scheduling algorithm was used to study the effect of labor time available on the sequencing of entree production activities as compared to conventional scheduling in a cook chill foodservice system. The technique provides a timely, relevant and feasible method of assisting management decision-making and monitoring of productivity in a cook chill food system.

Conclusions

Application of the COST ARREST model to an ongoing foodservice operation provided insight into the interrelationships of resources and to the effects of varying quantities of labor on the time required and sequencing of production activities. By comparing resource time requirements with duration of resource use, it was possible to see a clear relationship between what was to be done and how much available resource time was scheduled and unscheduled. When labor in excess of production requirements was available for entree production, the percentage of production duration that constituted delay increased. On the day when most labor was required and equipment needs most varied, delay was lowest in all production plans. It is reasonable to infer that optimal scheduling is possible when there are several alternatives for scheduling resources in a given time period.

Different sequencing of activities did not demonstrate major differences in production duration. Scheduling operations based on least labor time requirement did show some advantage over scheduling giving priority to longest production time. The advantage was not consistent on a daily basis.

Different resources are affected differently by variations in scheduling. Plan I with greatest amount of labor was least efficient of labor time among the three plans, but used ovens more productively than other plans. This may have been caused by the time when labor was available rather than amount of labor.

As a management decision-making device, COST ARREST has potential for long-term planning, for evaluating operation practices, and for periodic monitoring of resource utilization. It provides a technique that could be used for previewing effects of proposed changes on operational outcomes. The model offers a means for highlighting where changes in resource availability, requirement or cost have made it necessary to reorder priorities.

If a computer system was available which had the capability of using the COST ARREST program it would be feasible for a medium size hospital to gather data and routinely use the program for foodservice auditing. While data collection is time consuming, it provides useful insights and information that might otherwise be overlooked. Initial preparation of data for use in the computer is the most cumbersome aspect of program use. Most information, once coded, could be modified to reflect change without difficulty.

Concern has existed that computerization which relegates scheduling to a printout could have a negative effect on food production personnel. The value of the computerized resource allocation technique does not appear to be in daily operational scheduling but broader aspects of management functions.

The worth of the program comes from objectivity and the capacity to monitor input/output ratio. Where input is labor hours and equipment time and output is a required number of entrees, the program can pinpoint where changes have had either positive or negative impact. Objective measurement is a key not only to examining alternatives but also to establishing standards and judging results. Using a resource allocation plan, managers can determine whether stressful situations are a result of too little of a resource or simply of not having the right resource at the right time.

A cook chill food production system has few time constraints. When these impose an unnecessary burden on labor or equipment, the COST ARREST model has the potential to aid management to develop alternatives. Determination of time required of resources for production activities, an early step in developing COST ARREST input, provides information in inequities in work load imposed by the menu. As the basic planning tool in a foodservice operation, the menu can be modified with significant impact on smoothing resource requirements.

The computer model is not a substitute for the worker's ability to apply resourcefulness to unexpected problems. Until perfect criteria for sequencing can be programmed, the necessity for individual judgement will remain.

Recommendations

The COST ARREST model provides a useful tool for management decision-making and productivity monitoring in a cook chill foodservice system. With data accumulated for use with the program it would be possible to forecast additional requirements when a foodservice system anticipated expansion. With forecasts of increased food product requirements the need for additional personnel or equipment or revised scheduling could be foreseen. Periodic monitoring of productivity could be done by updating preparation requirements, adjusting for menu changes or alterations in type, quantity or availability of resources.

The logic used in the program has value for foodservice systems even when the computer program is not available. The COST ARREST model would be valuable for teaching the systems concept as applied to foodservice to graduate students.

Measurement has been frequently cited as a requirement for productivity improvement. Data from COST ARREST can be easily converted to measurement data, as percentage of productive capacity, resource units of input per productive output, delay periods and minutes scheduled. The program has the capacity of looking at different components of the foodservice system at different times as their significance varies.

The cost advantage of convenience versus conventional foods can be evaluated realistically using the model. Labor savings as often proposed are only time savings but not cost savings. Few employers would cut an employee's eight-hour day when a labor-saving purchase is made. With COST ARREST, management can examine delay time for both labor and equipment to meaningfully evaluate the possible advantage of convenience or conventional preparation.

Improvement in COST ARREST would be necessary for it to be useful for daily production scheduling. Simultaneous scheduling of labor and equipment when this is essential should be incorporated into the program. If possible, a maximum delay between activities within an entree would improve practical application of the technique.

Summary

In the health care industry emphasis on cost containment has led to increasing awareness of the need for improving productivity in hospital foodservice. Measurement and monitoring on an on-going basis are keys to productivity gains. The purpose of this study was to determine the feasibility of using the COST ARREST program for management decision-making and productivity monitoring in a cook chill food production system.

The COST ARREST model was used to study the effect of varying labor availability on labor and equipment utilization. Scheduling priorities were varied to see how changing criteria affected resource allocation. Conventional scheduling was compared with computer-generated activity sequencing. Data for the production plans were collected in an existing hospital foodservice. Menus, activity analyses, resources available and production requirements were obtained from the on-going operation.

Information from the foodservice system served as input for a computerized COST ARREST program which developed production schedules, allocated resources to specific activities at specific times, and printed a list of activities by number and scheduling priority. Three production variations for six days each were used with differing amounts of labor and differing scheduling priorities.

Results from the program were analyzed to determine production duration for labor and selected equipment, forced delay and productive delay as a function of duration, and labor cost daily and weekly under each plan. Sequence of activities in the COST ARREST plans were compared with conventional work scheduling.

Production plan III using 8.5 hours labor daily and giving priority to entrees with least labor requirement was most cost effective of the three plans from a labor standpoint. Plan II which also had 8.5 hours of labor time was slightly less cost effective than plan III.

Plan II had longest production time for scheduling criteria. Production plan I utilized ovens more efficiently than either of the other two plans. More labor was available in plan I than in II or III. Sequencing of activities conventionally was not observably different from COST ARREST sequencing. Slicer usage was more efficient in conventional scheduling than in the other plans.

The COST ARREST model was found to be a valuable tool for management decision-making and productivity monitoring in an actual foodservice system. Refinements are needed to improve the practicality of COST ARREST for daily production scheduling in a foodservice operation.

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APPENDIX

ITEM	AMOUNT	MON.	TUES.	WED.	THURS.	FRI.	SAT.
Roast Beef	Inventory						
1 round = 65 serv.	Forecast	4 rnds	4 rnds	4 rnds	4 rnds	4 rnds	4 rnds
	Prepare						
Turkey	Inventory						
About 30 serv/ turkey	Forecast	6	3	3	3	3	3
	Prepare						
Ham	Inventory						
About 30 serv/ ham	Forecast	2	6	3	3	3	3
	Prepare						
Chicken	Inventory						
80-90 per case	Forecast	1 case		1 case		1 case	
	Prepare						
Pork Chops	Inventory						
4 per lb.	Forecast	6 bxs	2 bxs	2 bxs	2 bxs	2 bxs	2 bxs
	Prepare						
Liver & Onions	Inventory						
40 serv. per box	Forecast	1 bx	1 bx	1 bx	1 bx	1 bx	1 bx
	Prepare						
Fish	Inventory						
15 serv. per pkg	Forecast	1 pkg	1 pkg	1 pkg	1 pkg	1 pkg	1 pkg
	Prepare						
Hamburger	Inventory						
20# box, 5 per lb.	Forecast	25	25	25	25	25	2 ½cs.
	Prepare						

Figure A-1. Production Sheet, Page 1.

RECIPE NAME_________________________ DATE________________

PRODUCTION ACTIVITIES LIST

NUMBER	ACTIVITY	LABOR TYPE	EQUIP-MENT	TASK PRECEDING	TIME IN MIN

Figure A-2. Production Activities List

VITA

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