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To the Graduate Council:

I am submitting herewith a dissertation written by Anne Looney Cook entitled "Quality Assessment of Meat Patties Cooked by Commercial Preparation Methods, Chill Stored, and Microwave Reheated." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Human Ecology.

Mary Jo Hitchcock, Major Professor

We have read this dissertation and recommend its acceptance:

Grayce E. Goertz, Ada Marie Campbell, J.B. McLaren

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

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Mary Jo Hitchcock

Mary Jo Hitchcock, Major Professor

We have read this dissertation and recommend its acceptance:

[signature]

Ada Marie Campbell

J. B. McLaren

Accepted for the Council:

L. Evans Roth

Vice Chancellor
Graduate Studies and Research

QUALITY ASSESSMENT OF MEAT PATTIES COOKED BY COMMERCIAL PREPARATION METHODS, CHILL STORED, AND MICROWAVE REHEATED

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Anne Looney Cook

December 1977

DEDICATION

This work is dedicated to the memory of

MARY LOUISA COOK
January 15, 1971 to September 8, 1972

whose brief life revealed that joy in living could grow from an internal spirit which would not be bound by handicaps from birth defects of spina bifida. For those of us who knew her as daughter and sister, Mary Louisa remains in our memory the example of how one may always search and reach outward for purpose and discovery.

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Personal acknowledgments are for my parents, C. Evans and Ruth Looney, who have always helped to open doors with whatever means and guidance they could offer. My deepest gratitude goes to Norvel Harper Cook, my husband, and to Chris and Wade, my sons. Each has sacrificed something of himself in my behalf.

ABSTRACT

Food quality assessments based on yield, cooking losses, and palatability factors were applied to a model food cooked by commercial preparation methods in a simulated chill/serve food service system. Frozen, soy-extended meat patties of a standard formulation represented a common food material flowing through a food service system. Batch sizes of 24 patties were prepared by (1) grilling, (2) baking by natural convection, and (3) baking by forced-air convection. Refrigerating of bulk packed samples and microwave reheating of plated samples concluded the input effects.

Cooked, whole meat patties were portioned with a specially designed cutting tool and recombined into composite patties which included portions of all three cooking treatments. After 30 sec microwave reheating of the composite patties, consumer panelists were presented three hot portions for tasting while two other portions were pooled by treatment for measurements of percent moisture and shear force.

Objective determinations of factors affecting quality included cooking losses, yield, moisture, moisture retention, and shear force index. Results indicated that greater percentage yields and fewer cooking losses occurred by the oven methods than by the grill method. Values for percent moisture and percent moisture retention were not significantly different for cooked whole patties but were significantly different for composite patties.

Portions of samples were sheared in the Kramer Shear Cell attachment to the Instron, universal testing machine. Shear force index was calculated as an indicator of tenderness of the cooked meat patties. No significant differences in tenderness due to treatment were determined for samples in this study.

Subjective assessments of factors affecting quality were made by a total of 89 consumer panelists. Appearance, flavor, juiciness, overall acceptability, and preference were scored. Samples baked by forced-air convection were scored highest for appearance and flavor. Tenderness scores were higher for the oven methods than the grill method, but differences were not significant. Significant contributions to overall acceptability were predicted for flavor, appearance, and tenderness. However, mean scores for overall acceptability were not significantly different and indicated "like slightly" on the hedonic scale. Sensory scores failed to identify a preferred method of commercial preparation for the meat patties in the study.

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CHAPTER I

INTRODUCTION

A growing management practice in the administration of institutional and commercial food systems is the separation of food preparation functions from food service functions. This practice permits offering the food at a time and place other than the end point of production (Livingston, 1968; David, 1973; Rinke, 1976). The development of this management practice stems largely from efforts to increase productivity, to conserve labor and food costs, and to bring food near to the service area and to the consumer. When a food system incorporates its own self-serving objectives to manufacture and package foods for delayed service, the system must include a low temperature subsystem for holding the preprepared food (Sell, 1973).

Preprepared foods must be quickly chilled or frozen for microbial safety. Each of these low temperature methods is being used in institutions such as hospitals, schools, colleges, mobile feeding programs, and vending operations (Donaldson, 1971; Blaker, 1973). Within an institution the emphasis is usually a chill/serve (Kaud, 1972) or a cook/freeze concept (Beyer, 1971; Glew, 1973). The expense of blast freezing installation which is necessary in the cook/freeze plan may be a deterrent (Beyer, 1971). The logical alternative in a low temperature subsystem is expanded refrigeration capable of chilling and storing at least one day's rations (McGuckian, 1969; Minor, 1972).

The on site reheating of chilled foods is possible with equipment using steam, forced-air convection, infrared rays and microwaves

(Livingston and Chang, 1972). The low cost installation, portability, space saving features of the microwave oven seem to favor its use by hospitals and other food service operations (Keefe and Goldblith, 1973). The rapid heating of chilled foods versus frozen foods encourages the use of the combination of chill stored, microwave reheated foods.

Objections to food quality are not uncommon among clients benefiting from an institutional food system (Livingston, 1972; Buchanan, 1976). In a sense there are captive clients. Failure to produce food of acceptable quality may result from lack of proper training of the cooks, lack of adequate supervision, or lack of basic knowledge in food science principles of the production management (Willett, 1969; David, 1973). Needs for menu diversity, tradition, and regional preference are noted as influences on cooking methods as well as on cooking volume (Ronan, 1973).

Information is needed concerning optimum treatment mix in food production and service systems. Method of cooking, level of low temperature holding, and method of reheating food could serve as bases for decision making about food quality (Blaker, 1973; David, 1973). Much information has accumulated for the overall management feasibility of advance preparation, low temperature holding, and on site reheating. Little information is available on the assessment of the quality of food subjected to these treatment combinations prior to serving. Excessive handling of food materials as might occur in turning, pressing, and piercing meat, over stirring of mixtures, too large batches, and inappropriate heat input can lead to food quality deterioration. Poor techniques of food production resulting in loss of any food's integrity are little gain for the management of the system (Willett, 1969).

The objective of the investigation was to evaluate meat patties for factors of acceptability--appearance, flavor, tenderness, juiciness,--for preference and for cooking losses at the point of service after they were prepared by each of three commercial cooking methods. A single formulation, frozen meat patty was used as a model food for the assessment of quality resulting from grilling, baking by natural convection, and baking by forced-air convection.

The null hypothesis for the investigation was: meat patties cooked by three common, commercial methods--grilling, baking by natural convection, and baking by forced-air convection,--in a chill/serve system, do not differ as to appearance, flavor, tenderness, juiciness, preference by consumer panel, or cooking losses.

Management decisions which should be facilitated by the collected data pertain to the selection of equipment for installation, expansion or renovation, the development of productivity standards, the training and scheduling of employees, the planning of food item frequencies in menus, and the accounting of food yields.

CHAPTER II

REVIEW OF THE LITERATURE

A separation of food preparation from food service functions within conventional food systems was described beginning in the mid-1960s (Livingston, 1968; Rinke, 1976). This trend in separation of functions reflected a decade of administrative efforts to increase food system productivity with new equipment and new materials as counterpoints to wage demands, limited availability of manpower with needed skills, and rising food costs. Control for food quality when reported reflected individual system adaptations to change in the separation of preparation and service functions (Willett, 1969; Pinkert, 1973; Blaker, 1973; Glew, 1973). Predicted continuation of separated production and service functions pointed to unresolved controls for food quality in modern systems (David, 1973; Powers, 1976).

I. TRENDS IN FOOD SERVICE SYSTEMS

A definite trend toward centralized, mass food production with service of that food being separated in time and place from the production site was noted by Livingston as early as 1968. Improvements in system productivity through mechanization or automation were asserted for both production and service functions. However, the public's demand for human input to the service functions placed emphasis on mechanization in the food preparation functions. Systematic approach to designing a food service facility with departure from convention involved a three part plan integrating studies of cost, function, and acceptance. Systems analysts (Flambert and Niebert, 1970) and experienced administrators (Donaldson, 1971; David, 1972; Blaker, 1973) additionally recommended systematic approaches to designing and managing food service facilities. There seemed to be concurrence among them for a basic concept about food service systems.

> Although problem-solving approaches and system components are transferable, systems as such are not. No two . . . share identical sets of problems, so no single system, representing a total solution to a single set of problems, can be universally transplanted without risk of failure (Livingston, 1972).

Hospital administrators were cautioned not to be charmed by "stylish" food systems which promised undocumented lower costs and extreme working simplicity "without experiencing the food" (Willett, 1969). Quality food from any system depended upon the premise that a million years of biological satisfaction in eating cannot be dumped for the sake of something new.

Many changes toward industrialization of hospital dietary departments succeeded in meeting objectives for economy (Donaldson, 1971). However, the effect of these changes on food quality was a primary concern and one for which research was advocated for defining product quality or product performance in the increasingly mechanized food systems. Innovations in hospital dietary departments in the direction of community social services were suggested as being made possible by the separation of food producing and food serving functions.

Continuing trends in food service administration were identified as systems analysis and increased technology to treat continuing symptoms of rising costs and decreasing productivity (Blaker, 1973). The major concern of institutional administrators was the development of an internal supply of convenience foods through the use of on premise production and on premise low temperature storage, chiefly freezing. Feasible on premise production and storage necessitated careful appraisal of conversion of conventional methods and acquisition of expensive support systems to frozen food processing.

Innovations in hospital food services (David, 1973) included more centralized food production with satellite services, augmented plans for preparation of chilled food, shared services such as purchasing, and increased automation in tray assembly and transport. One means of operational streamlining was the timed separation of functions between preparation and service of food. Wiser use of resources to meet the objective of providing high quality food and service to patients and personnel was advised. With an emphasis on quality of food and service, David outlined both quantitative and qualitative measurements which could be applied to practically any institutional food system.

European food systems where automation of food production is highly correlated with industrial techniques were referenced (Sell, 1973). Volumes of 900 portions prepared in 25 minutes by automated equipment were compared to 900 portions prepared in 90 minutes by nonautomated but standard, commercial equipment. Speed of production and product uniformity were benefits of high volume production. Efficiency of a system with high volume equipment required 500 meals or more. The kind of automated food systems described were typical where volume was more important to management than was menu selectivity to the patients or clients.

From a current, inside-the-industry viewpoint, Powers (1976) projected directions for food service in 1985. Bases for prediction were gathered by extensive survey of market demands, manpower needs, and government sponsored food services. For meaningful growth to occur in food service productivity, the focus must change from the "traditional view of a craft dominated industry." Centralized food production systems were assessed, and an expansion of this kind of system was predicted as a result of static worker productivity and social legislation which drives wages inexorably upward. Trends toward menu simplification stemming from deemphasized culinary skills and fast food appeals were indicated. Budgetary constraints were predicted to force administrators increasingly to make economical uses of customary foods and to adopt new foods. Centralized food production units, i.e., factories and commissaries, hold great promise for supplying well prepared food for many points of service.

The trend that food can be centrally prepared for subsequent serving without significant loss of quality was affirmed (Powers, 1976). Sameness of food among serving outlets may be dispelled by attentions to serving techniques and to differentiating establishments. Increasing sales, increasing government sponsored feeding programs, and reducing dependence on skills are trend components which are reinforced by the economic advantages of centralized food production.

Service rendering industries were challenged to increase productivity through industrial techniques and to offer mechanized, less "craftsman-like" services by adaptation of available technologies (Levitt, 1976). "Hard, soft, and hybrid technologies" adaptable to a food service system include the use of convenience foods, job specialization with rational division of labor, and electronic data processing. Based on the principle of magnitude as being rudimentary for a meaningful industrialization process, centralized food preparation is a specific stride toward industrialization. Delivery of services to recipient sites is interpreted as the on site serving function of a food system. Many administrators may feel that they have already met the challenge for industrializing food services, but thinking new dimensions for old problems is the basic challenge to service rendering industries.

Conventional food systems necessitate long, overlapping duty hours, bursts of frenzied activity alternating with lulls, and many hands to produce and serve products with peaks of serving quality disproportionate to their make-ready times. The use of convenience foods which have varying degrees of readiness is a step forward from the conventional food production function (Goldberg and Kohlligian, 1974; Rinke, 1976).

Implementations of convenience food systems minimized or eliminated the food production functions by reliance on extensively preprepared foods (Quam et al., 1967; Byrd and Morrow, 1971; Harder, 1973; Reid, 1973; Hancock, 1973; Rinke, 1976). The finishing, usually reheating, of preprepared foods may or may not be separated in time or place from the serving function. Limited availability and limited distribution of well formulated, fully prepared foods minimized development of total convenience food systems. Furthermore, when the supply of these kinds of convenience foods was not adequate and production labor force was not replaced, operating costs were high (Pinkert, 1973; Livingston, 1972;

Harder, 1973; Goldberg and Kohlligian, 1974; Rinke, 1976).

Assuming that entree items are available as frozen commodities, an institution must invest in adequate storage space for the required volume. Institutions have become self-producing and self-serving when the availability of suitable entrees was too limited to support the system's needs. Capital outlay and space requirements for refrigerator and freezer storage should be considered as part of the system (Blondeau and David, 1971).

From systematic analyses of needs, administrators generally recognized that the food service industry relies fundamentally on people and perishable products, both subject to wide variability (Flambert and Niebert, 1970; David, 1972, 1973; Blaker, 1973). In addition, consumers of the food service industry have become mobile and affluent enough to influence changes in both the industry's products and its services (Sherck, 1971; Levitt, 1976; Powers, 1976). Out of a need to produce varying quantities of food with a minimum of trained personnel and to adequately supervise the production function and the service function, food systems administrators, chiefly in institutions, arrived contemporarily with modern food systems which have unique, functional dimensions.

Four commonalities of purpose distinguish these modern food service systems: (1) sustained food production activities which are chiefly heat input methods to achieve edible and microbially safe food; (2) prompt heat removal from food with subsequent safe, low temperature storage; (3) transport of chilled food to service sites; and (4) reheating of designated foods at the point of service. Differences in methods among the systems exist with regard to portion versus bulk packaging during the heat removal step, low temperature storing by refrigerator or freezer, and amount of food being reheated at planned serving times. Consequently, systems components for flow of materials through preparation, packaging, storing, transporting, and reheating cycles are dictated by the particular needs of the system.

Distinctly named food service systems emerged with the industrialization of the separate production and service functions. "Nacka" (Bjorkman and Delphin, 1966), "AGS" (McGuckian, 1969), "Ready Foods" (Beyer, 1971; Pinkert, 1973), "Cook/Freeze Catering" (Glew, 1973), "Chill/Serve" (Kaud, 1972; Anon., 1973), "Cooking Street" (Ronan, 1973), and others (Sell, 1973) were designed on the principle of magnitude (Levitt, 1976). Economic advantages of centrally prepared foods and separated services championed their development (Ronan, 1973; Sell, 1973; Powers, 1976).

The industrialization impact on food service systems appeared early at Stockholm, Sweden's, Nacka Hospital (Bjorkman and Delphin, 1966). The food preparation functions of 43 hospitals were centralized. Since the serving locations were widely separated, deliveries were expensive. Research indicated that with refrigeration of the prepared food, deliveries could be made at intervals up to once a week. Essentials of the plan dictated commonly used quantity cooking methods with internal temperature of portions reaching (176°F) 80°C. The hot food was portioned usually five servings per plastic bag, and the vacuum sealed plastic bags were treated in a boiling water bath for 3 min. Rapid heat removal was achieved by passing the bags through a cooling tunnel with cold running water. Finally, the dried-off bags were refrigerated at

(40°F) 4°C or less. Reheating of the Nacka portions was by boiling the chilled bags for half an hour before plating.

Bjorkman and Delphin (1966) claimed that the Nacka System food has the "same nutritional value and the same bacteriological condition as freshly prepared food." Their fundamental premise of good quality was based on the quick chilling and refrigerator storing of the cooked food at a temperature "which is known by long experience to be suitable for food." Quality control, as reported, focused primarily on hygiene. Extensive microbiological tests were conducted. Organoleptic characteristics were judged acceptable by both special groups and laymen, although standards were not described. In comparison with conventional food systems, the Nacka System is claimed to be economically and hygienically beneficial.

The Anderson-Greenville-Spartanburg System (AGS) was based on the Nacka principle of vacuum-packaged, refrigerated foods (McGuckian, 1969). Name of the system, AGS, reflected the geographic region which supported its development--Anderson, Greenville, and Spartanburg, South Carolina. Maximizing advantages of the conventional and the convenience food systems, the AGS System targeted getting food with peak quality and temperature to hospital patients. The choice of refrigeration over freezing for the low temperature holding was based on the probability of uncontrollable temperature fluctuations of frozen foods in distribution channels and the resulting unfavorable effects on food quality. The investment in space and labor requirements for freezing and monitoring the thawing foods also was considered a less desirable plan.

Refrigeration of pasteurized, ready-to-eat foods became the focus of the AGS System (McGuckian, 1969). This method of preservation was less costly, processing techniques were simpler, and fewer changes in food integrity resulted than in freezing preservation. Another fundamental reasoning was that regionally prepared foods under refrigeration would be preserved long enough for orderly consumption. AGS food preparation methods generally reflected a broad range of conventional procedures. Shortening the length of time of conventional cooking was discovered early as a quality control measure. The pasteurization treatments were found to finish cooking or even to fully cook some of the vacuum packaged foods.

In the AGS System heat removal began immediately after pasteurization when the pouches were chilled quickly in an ice water tank. Storage of food was in a walk-in refrigerator maintained at 28°-32°F (-2-0°C). These procedures were claimed to inhibit growth of any harmful bacteria and to permit a "proven shelf life of at least 60 days." However, regular turnover time of the inventory was implied to be only a few days.

Food quality attributes were tested repeatedly by AGS System personnel. Aroma, first, and flavor, second, were quality attributes emphasized most by the developers. Patient reactions to the served, hot food were reported favorably. Similar to the Nacka System, AGS food pouches were heated in a hot water bath for 30-40 min to reach an internal temperature of 160°F (71°C). The hot food was plated, transported to a patient serving site, and insured hot by receiving a 10-20 sec microwave exposure immediately before presentation.

The early successes of the AGS System were documented by substantial savings in space, conventional equipment, and production personnel.

Expansion to a regional commissary serving more than the three hospitals in the three cities was considered. Adaptations of the AGS System were indicated for other mass feeding operations such as schools, colleges, institutions, military installations, hotels, and restaurants. McGuckian (1969) recommended the system's utility especially for institutions with facilities for multiunit food services.

"Ready Foods," a term introduced by the Research Department of Cornell University's School of Hotel Administration, has become practically generic in the food service industry (Pinkert, 1973). It describes a system of centralized production of foods on the same premises where they are later served. The foods are frozen, usually after portion packaging, stored until requisitioned, tempered, and reheated. A wide range of foods may be processed by this kind of system. The only requirement is that the foods be successfully frozen and reconstituted (reheated). Since its first identification, the Ready Foods System was viewed as a logical and practical system for hospitals. Modified diets and delayed meals, both special concerns in hospitals, may be managed with utmost accommodation to the patients (Beyer, 1971; Pinkert, 1973; Blaker, 1973; David, 1973).

A notable application of the Ready Foods System was made at the St. Elizabeth Hospital in Lincoln, Nebraska (Beyer, 1971; Pinkert, 1973). Producing about 1700 portions for patients per week based on a level of 25-125 portions of 10-14 different items each day, the system maintained a 20-22 day inventory of about 4200 frozen entrees. Food production for the cafeteria was over 1000 portions weekly. For the dual channels of service, the system personnel portion packed for patients and bulk packed in standard steam table pans for the cafeteria. Processed foods were reportedly chilled before packaging and freezing. The Ready Foods were quick frozen to a core temperature of 0°F (-18°C) and then transferred to -10°F (-23°C) storage until requisitioned for service.

Estimated portions of food were tempered overnight in a 38°F (3°C) refrigerator. Any food item not used after being withdrawn from the freezer was dated and held in the tempering refrigerator up to 5 days for possible use. Tempered food portions for St. Elizabeth patients were transported under refrigeration to serving galleys for finishing. Foods were unwrapped, plated, and heated by microwave ovens. The serving function per tray averaged 90 sec for reheating the food and for final assembly of all the meal's components (Beyer, 1971).

Quality standards at St. Elizabeth's encompassed microbiological standards almost entirely (Beyer, 1971). Development of recipes for food meeting freeze-thaw stability was a part of the system's preplanning (Pinkert, 1973). Methods of assessment of qualities relating to palatability and yield were not specifically identified. Rather, the system was favorably appraised as providing the means for expected levels of productivity and the improvement in quality and variety of foods available for service at any hour of the day.

"Cook/Freeze Catering" System with similarities to Ready Foods for freezing prepared foods appeared in England (Glew, 1973). Developed at the University of Leeds, the system pioneered at the Hospital for Women and later expanded to support a school lunch program. The objectives of the system were to optimize equipment used for production and reheating. Recipes using foods portioned for their densities were developed so that reheat time and temperature were standardized. Cooked portions were frozen quickly in molds, released, packaged by standardized multiples in system designed pans, and stored in freezers. Frozen packages of food were transported on the day of service. Reheating of the pans of food was by forced-air convection.

The Cook/Freeze Catering System produced 12,000 portions per week for service in the hospital and 60,000 portions per week for service in the school lunch program. For this system's centralized, mass production and satellite service, its proponents claimed cost benefits, nutrient retention, and palatable foods (Hill and Glew, 1974).

Methods for controlling quality of foods prepared in the Cook/Freeze system were implied to consist of recipe formulations and portion quantities for uniform heating. Assessment of quality involved judging of selected foods by a screened taste panel by means of a modified duo-trio test including controls of fresh prepared batches (Hill and Glew, 1970). Depending on the food, delays up to 1 hr between cooking and freezing were not significant for effect on sensory attributes. For omelettes and macaroni-cheese significant changes in sensory properties occurred after 20 min. In the development of the system, Hill et al. (1970), using 20 panelists, conducted preference tests on seven products and found no significant difference between any of the cook/freeze and fresh products tested for consumer acceptability.

Implementation of a chilled food concept (Kaud, 1972) followed a critical evaluation of patient food services at the University of Wisconsin Hospitals. The system's two major premises were: (1) chilled food retains nutrients longer and is less perishable than food held hot;

(2) the serving function may be scheduled to avoid peak work loads. Essentials of this system were on site food production, incorporation of suitable convenience foods, bulk storage by refrigeration for approximately 24 hrs, centralized tray assembly, refrigerated transport of trays, and, finally, microwave reheating of chilled portions.

Several anticipated gains were reported after 2 years of chill/serve operation. The dietary staff was reduced by 44 full time equivalent positions, productivity index for patient meals climbed from 1.85 to 2.16 and for cafeteria meals from 4.18 to 6.70, and patient food costs dropped by 9%. Sanitation levels improved over former levels. Acceptance of the foods produced by the chill/serve concept was ascertained by survey. Reportedly, patients indicated better meals, more menu variety, and more efficient service, but the baseline for their comparisons was not reported (Kaud, 1972).

Other applications of the chill/serve concept were outlined for Marriot In-Flite Service, a commercial airline caterer, for the University of Illinois, Urbana-Champaign food services, and for Wauwatosa, Wisconsin, school lunch program. These large systems all were described as having commissaries and refrigerated storage. Otherwise, the systems had different objectives (Anon., 1973). Of these three systems the school lunch program seemed most like the hospital application (Kaud, 1972). Of note is that bulk lots of food in standard pans were managed throughout the various handling cycles for the school meals. Formal quality assessment of foods prepared by these three systems was limited.

The use of regional commissaries for food production, such as the Wauwatosa school food service, was justified if the products provided were reasonably priced and suitable to the user's menu. Commissary produced foods should meet needs for portion sizes, local variations in taste, and any other special requirements of the using facility which cannot be met by national producers or private-label packers (Willett, 1969). Five commissaries were illustrated, all of which regionally distributed chilled food (Minor, 1972). Of the five food systems, one used a pasteurization technique; one was in essence a food factory; and three used conventional cooking methods.

Economic facts supporting growth in commissary type food systems included market demands by consumers for moderate priced food with a minimum of services. Another economic fact facilitating commissary food systems was the location of plants in industrial districts with the expected advantages of space, labor, and transport vehicles. Food eaten away from home was one out of five meals in 1970. Growth in sales volume was greatest in food service establishments such as schools, colleges, hospitals, nursing homes, industrial plants and offices (Minor, 1972).

Mass food producing installations in German institutions where daily production was 8000 to 10,000 meals were called "cooking streets" (Ronan, 1973). Food materials in the systems were processed in a straight flow from receiving to cooking to freezing. The highly mechanized pieces of equipment required few people with few skills to manage the food flow. The cooked food was generally bulk frozen in standard metal pans which could be used directly for reheating and serving. The "cooking street" was termed applicable for institutional operations in the United States and for commissary production with satellite services, the predicted basic functions of food services in 1985 (Powers, 1976).

An overview of the food systems itemized above which have distinct functional dimensions for food production, low temperature holding, and serving may be summarized on the basis of the terms used to describe them. The terms "centralized food production" and "commissary production" were used somewhat interchangeably among those contributing information. However, two conceptual differences seem to be apparent--number and volume of individual menu items produced and extent of automation of the system. Centralized food production was the term applied to hospital situations where many items were separately produced to meet demands of selective and modified menus. In the central production facility, productivity increases reflected the system's mechanization and uninterrupted food preparation procedures (McGuckian, 1969; Beyer, 1971; Pinkert, 1973; Kaud, 1972; David, 1973). Where there was a centralized food production function, there was likely to be a food serving function separated from production principally by time.

Commissary production was the term applied when significantly large volumes of food with few menu items were processed at any one time. Commissaries were automated and factory-like. Where there was a commissary production function, satellite feeding was the ultimate objective, and separation in place as well as in time of the production and serving functions was necessitated.

Food service systems with separated functions were described as having a "thermic break" (Sell, 1973). Use of the term thermic break, meaning a short-time preservation of foods bridging hours, days, or weeks, has acquired almost generic connotation. Foods should be of good quality before entering the thermic break. Foods subjected to a thermic break must be palatable, nutritious, and appealing after reheating. Temperature controls of thermic break usually are either very low refrigeration at <40°F (<4°C) or freezer maintenance at -10°F (-23°C) (McGuckian, 1969; Beyer, 1971).

Many kinds of equipment are available for heating foods from a thermic break as a fundamental part of the serving function. Decisions for this part of the system should reflect type of food being served, original preparation methods, quantity to be heated, the extent of temperature change required, the speed of heating, equipment cost, and the resulting quality of the food (Co and Livingston, 1969; Donaldson, 1971; Livingston and Chang, 1972).

Relationships between heating methods and heat transfer are important considerations in the reheating of chilled or frozen food. Although conduction, per se, seldom is used for the obvious reason of scorching food surfaces before reaching desired internal temperatures, conduction is an important part of most heating methods. Bake ovens as used for pizza and breads are sometimes referred to as conduction ovens although more properly these ovens may be called conventional ovens which operate by natural convection (Co and Livingston, 1969; Anon., 1972b; Anon., 1975; Livingston and Chang, 1972; Sell, 1973).

Convection is a term often lacking precise identification in the literature. References may include the description for forced-air convection, but, generally, this description merely is implied. The forced-air currents accelerate heat penetration into the food thus decreasing overall heating time (Co and Livingston, 1969; Livingston and Chang, 1972; Sell, 1973; Anon., 1975).

Applications of forced-air convection for reheating frozen foods were reported for the Cook/Freeze Catering System (Glew, 1973) and for chilled school lunches from commissary production (Anon., 1973). Ovens of varying sizes were described. This equipment was claimed to be the most versatile for batch reheating of either frozen or chilled foods whether bulk packed or single plated. Where portions and serving techniques were alike, the forced-air convection oven was a practical consideration for moderate batch turnover (Livingston and Chang, 1972; Sell, 1973).

Radiant energy sources from both infrared and microwave systems are innovative means of batch reheating foods (Livingston and Chang, 1972; Sell, 1973). Some infrared systems use pulsed rays to minimize scorching the food. An infrared system needs a warm-up time of about 30 min after which time it may have a cavity temperature of 600°-850°F (316°-454°C) which brings food from 34°-160°F (1°-71°C) in about 30-40 min. Since chilled foods have been found to reheat more uniformly and in less time than frozen foods, the use of an infrared system to reheat chilled foods would be applicable to either ready foods systems or chill/serve systems. Depending on equipment size and number of units, 12-20 or more meals can be heated simultaneously in 30-40 min (Mellios and Strickland, 1972; Livingston and Chang, 1972; Sell, 1973). This is a time saving advantage declared by some users over the single meal microwave reheat which averages 90 sec per meal (Beyer, 1971). Microwave oven systems for batch reheating are conveyorized and integral to very large serving functions in some European institutions (Livingston and Chang, 1972; Sell, 1973).

The most commonly used method of reheating portion chilled foods is by microwaves (Beyer, 1971; Keefe and Goldblith, 1973; Ricklin et al., 1975). This method has increased in use for providing the service of hot food to the consumer. Chiefly used in hospitals to support the serving function, the microwave oven reportedly offers many advantages to feeding patients whose eating schedules may not be congruent with rigid serving schedules. The single unit microwave oven generally is installed as a galley fixture or is built into a chilled transport system (Keefe and Goldblith, 1973; Ricklin et al., 1975).

Even before the current popularity in hospital food services, microwave oven manufacturers predicted the oven's use for portion heating at lunch counters, restaurants, and vending outlets (Anon., 1968). Intrinsic values to using the microwave oven include the cool-to-touch containers which are handled safely by workers, food which remains plated during reheating, and documented claims of microbial safety when refrigerated foods are microwave reheated (Anon., 1972b).

Steam and water application for reheating food were reported to be minor considerations industrywide except for the Nacka and AGS Systems (Livingston and Chang, 1972). A short microwave charging after plating and before serving completed the reheating phase in the AGS System (McGuckian, 1969).

The uses of reheat methods for chilled and frozen foods are reported as fundamental parts of serving functions which are separated in time and space from production functions. The choice of a reheat method by an institution is shown to augment basic food preparation methods and further to reflect the food's chilled or frozen state at the end of its thermic break (Livingston and Chang, 1972; David, 1973). The Ready Foods System and its imitators have increased their thermic breaks to include a tempering time for the rapid reheating of food by microwaves (Byrd and Morrow, 1971; Pinkert, 1973; Ricklin et al., 1975). Batch heating methods are reported to have particular success with standard menus (Sell, 1973).

II. FOOD QUALITY CONTROL

Quality checks of food in stages of production are found in reviewing food service systems having separated functions. Few descriptions exist specifically defining quality attributes and methods for assessment. Quality in food service has a meaning of product consistency for the consumer and a meaning of economic feasibility for the system's administrator. Salability of food in a commercial establishment indicates an acceptable quality level. Consumption of food is an indication of acceptable quality level by the repeating consumer in an institution. These definitions for quality in food service and steps to take in deriving quality which meets both definitions are basic to productivity and economic gain (Buchanan, 1976).

In developing the AGS System, McGuckian (1969) emphasized the administrator's responsibility for quality.

> If food of poor quality is prepared, packaged, and processed, the packaging and processing can do nothing to improve quality.

McGuckian stressed that recipes must be tested, adapted to the system, and followed thereafter. Processing procedures such as pasteurizing, vacuum packaging, chilling, and others should be examined for their effects on food quality.

Apparently, the adaptations of conventional recipes for freeze-thaw stability, refrigeration time, cooking time, batch levels, and special interest items were made by the various systems. Effect of reheating the food as an input to the recipe formulations for the system was cited for Ready Foods, Cook/Freeze Catering, AGS, and Chill/Serve (Beyer, 1971; Glew, 1973; McGuckian, 1969; Kaud, 1972). The extent to which effect of reheat treatment influenced recipe formulation has not been documented except for the Cook/Freeze Catering System. Food portions were predetermined on the basis of quantity that would reheat from a frozen state in a forced-air convection oven within a specified time (Hill and Glew, 1974).

Assuming that food quality standards have been established for a system in accordance with the various input processes, a quality maintenance program could be developed with guidelines that McLaren (1973) described for one conventional food service system. To maintain quality standards, five foods were selected randomly at each meal and critically scored for temperature and acceptability factors, especially appearance. Scoring was performed in the tray assembly area and then at the point of serving. Ideally, immediate correction could be made before all trays were assembled.

Food quality as determined by recipients of food from systems using a thermic break was affirmed by the various supporters to be acceptable. Surveys and opinionnaires of hospital patients were the usual basis for claim (McGuckian, 1969; Beyer, 1971; Kaud, 1972). Having hot food at the point of service was a frequently mentioned objective easily attested to by the consumer in assessing quality.

The favorable effect of centralized production on food quality was specifically noted for modified menu components in hospital food service. Batch levels of 25-125, as opposed to fewer than 25 portions, were easily managed, and the portions on inventory were then available on demand (McGuckian, 1969; Pinkert, 1973).

Supervision of the production function without interruption by the serving function was implied as another effort to control food quality. Few employees monitoring few pieces of equipment and reducing the likelihood of error in formulation and in heat application also were implied controls (Beyer, 1971; Sell, 1973; Goldberg and Kohlligian, 1974; Rinke, 1976). As a result of the centralized, adequately supervised production function, recipe yields have improved (Rinke, 1976). Substantial reduction in meat shrinkage specifically resulted for the AGS System (McGuckian, 1969).

Administrators, having several latitudes for establishing quality standards, tended to focus primarily on developing microbiological standards in their systems. Once established for the particular system, bacteriological counts were relied upon principally as indicators of quality of the food (Bjorkman and Delphin, 1966; McGuckian, 1969; Beyer, 1971).

Kossovitsas et al. (1973) studied sensory attributes and wholesomeness of chilled stored versus frozen stored prepared food in relation to claims made by the developers of the systems. The chilled stored foods simulated the Nacka and AGS Systems for pasteurization of vacuum packaged foods and refrigeration. Evaluations were for microbiological levels relative to specific standards for two organisms (C. perfringens and

Salmonella) for retentions of ascorbic acid, thiamin, and riboflavin, and for acceptability. Freshly prepared samples were examined along with the stored samples at 15 and 30 day storage intervals. Pasteurization proved to be effective in destroying both organisms, and freezing expectedly eliminated C. perfringens but not Salmonella. Nutrient retentions in comparison to fresh samples were considered to be good, especially through the 15th day, with values slightly higher for refrigerated samples than frozen samples.

The third probe of the study was an organoleptic evaluation to rank fresh, frozen, and chilled samples for acceptability as determined by a "bench" panel. Fresh samples always were graded organoleptically superior. After 15 days of storage, the refrigerated and frozen samples were judged not significantly different for appearance, flavor, and consistency; their acceptability was implied. After 30 days of storage, the refrigerated samples were deemed unacceptable while the frozen samples were acceptable but inferior to the fresh (Kossovitsas et al., 1973).

Microbiological levels, TBA values, and acceptability of refrigerated meat loaves compared to fresh meat loaves were factors used as criteria of quality (Zallen et al., 1975). Cooked and cooked-pasteurized meat loaves were held at two controlled storage temperatures, 32°F (0°C) and 42°F (6°C), for 9 days, simulating a chill/serve system. Rather than be vacuum packaged, the samples were cooked, wrapped, and stored in individual pans thus minimizing handling of the product. Results indicated that pasteurization made no significant differences for microbe colonies and acceptability as compared to nonpasteurization of meat loaves. Microbial safety persisted up to 9 days. Palatability, on the other hand, was judged acceptable for up to 4 days.

On the basis of the two preceding studies, food acceptability may be maintained within a chill/serve system for a 4 day storage without the necessity of pasteurizing or vacuum packing. If longer storage is required, microbial safety of the food with or without pasteurization could persist up to 9 days. The palatability factor, reported as acceptable up to 15 days, may be related to the vacuum packaging before refrigerating. This relationship could be a basis for future investigation (Kossovitsas et al., 1973; Zallen et al., 1975).

In evaluating freezing procedures for effects on quality of food being stored between production and service, cryogenic freezing (freezing with liquid nitrogen) was advocated as superior to blast freezing [freezing at -40°F (-40°C) to a food core temperature of 0°F (-18°C)]. Structural changes would be fewer because of the more rapid freezing by liquid nitrogen. Willett (1969) reported this method of freezing as being successfully used by commissary systems. A volume of food was necessary to justify the expense of initiating cryogenic freezing.

The choice of freezing method and its subsequent effect on food quality would seem to stem from the volume of food being produced and whether or not the food remains within the system for service. Similarly, the choice of freezing versus chilling would reflect the system's capital resources to install any such system and space wherein to operate (Beyer, 1971; Blondeau and David, 1971; Kaud, 1972). The food system choosing freezing must plan not only for the blast freezer cost and space but also for tempering space. The tempering space needs to be refrigerated separately from "raw food" storage (Beyer, 1971; Kaud, 1972). Whatever the method, the constancy of storage temperature is fundamental to maintaining food quality.

The development of quality standards for foods in the new food systems is a repeated challenge by research-minded analysts (Livingston, 1968; Willett, 1969; Blaker, 1973; David, 1973). Quantitative methods for quality control similar to those used in industry for product development should be applied everywhere possible for regulating the food as it flows through the system. Food quality control must change from simple product inspection to product review from the initial menu plan to the consumer's use (David, 1973).

Advocated research is minimal because of difficulties in sensory impaneling and because standards for measuring total qualities of food and services are lacking (David, 1973). The use of consumer panels has limitations for discreteness (Abbott, 1973), but, carefully planned, these kinds of panels have yielded important data. Quam et al. (1967) reported that student consumer panelists in a college dining hall were better predictors of acceptability than were panelists from the food production staff when comparing fresh to convenience entrees.

A concept of food quality control related to fundamental labor times in hospital dietary departments for food production, transportation, and service was offered (Willett, 1969). Since food production time was least among the items, careful planning for production methods was advised so that this time value did not become proportionately larger. Central to control for food quality was the need for clearly understood food handling procedures such as using equipment fully, cooking covered or uncovered, using definite indicators of doneness, and prepreparing whenever possible. Furthermore, employee scheduling was incorporated in the concept.

III. IMPLICATIONS FOR RESEARCH

From the literature one may assume the current characteristics of centralized food production functions to include the use of conventional equipment, designed for institutional and commercial performance and the use of modified conventional recipes (Kaud, 1972; Blaker, 1973; Rinke, 1976). Commercial equipment is usually analyzed for its energy requirements, capacity, operating ease, maintenance ease, and similar utilitarian aspects before installation (Livingston and Chang, 1972).

Comparison among pieces of equipment capable of giving similar treatment effects has not been reported as a basis for management decision regarding food quality in a food system with separated functions. When decisions are made as to the basic concept of the system, whether cook/freeze or chill/serve, the thermic break and reheating treatments become standards, each having an effect on quality (Pinkert, 1973; Sell, 1973). These standards may be readily controlled by time and temperature.

The use of conventional, commercial equipment in a centralized food production facility might be evaluated for effect on food quality within an operational or a simulated food service system. Measurements of sensory attributes, yields, and cooking losses would contribute pertinent data for directing management's planning and controlling of food production and service.

CHAPTER III

METHODOLOGY

The objectives of this study were to evaluate factors affecting acceptability and cooking losses of meat patties prepared by three commercial cooking methods--grilling, baking by natural convection, and baking by forced-air convection. A chill/serve food system was simulated involving bulk packing of the food for 24 hr refrigerated storage followed by microwave reheating of the cooked patties at the point of service. Meat patties from two lots and in two replications were evaluated for factors of acceptability--appearance, flavor, tenderness, juiciness--and for preference by a consumer panel. Batch cooking losses, shear force values, and percent moisture values were determined. The investigation was based on the following model as shown in Figure 1:

Raw Meat Patties
Frozen, Preportioned, 3 oz

Grilling, Griddle-type	Baking, Natural Convection	Baking, Forced-Air Convection

Chill Stored
24 hr (Bulk)

Microwave Reheating
(Portioned)

Fig. 1--Model for investigation.

Source of the Meat

Two lots of frozen, ground meat patties of 79% USDA inspected beef and 21% hydrated soy granules, wet weight, were obtained from a local meat packing company (East Tennessee Packing Company, Knoxville, Tennessee) and were from the company's regular production on 2 consecutive days. The house formula product, called Item 13, conformed to the #1136 National Association of Meat Purveyors (1967) specifications for grind and for proportions of lean meat and trimmable fat (Table 1).

The manufacturer of the soy product (Griffith Laboratories, Inc., Alsip, Illinois) identified it to be a defatted, structured soy flour food ingredient, meat-like in structure, having a fiber and cell structure closely resembling skeletal meat tissue. The product was 1/8 in. (3 mm), irregular shaped granules. Properties indicated for this product included bite and appearance of meat and ability to withstand extreme processing conditions, including freezing, thawing, boiling, frying, and retorting (Davidheiser, 1977).

Meat patty dimensions were 4 in. diameter by 3/8 in. thickness (approximately 10 cm X .9 cm), round, and smooth surface, and weighed 3 oz (85g) (Prestwood, 1976). Patties were frozen individually by the nitrogen tunnel process and were packaged in four 10-lb (4.54 kg) units per carton. Each carton represented a separate lot. The two lots were delivered frozen on June 8, 1976, and were stored in a Victory, 2-door, upright freezer (Model FA206). The freezer temperature cycled between -4°F and +6°F (-20°C and -14°C). The two large cartons (40-lb, approximately 18 kg per lot) remained unopened until preliminary

Table 1--Formulation of the meat patty product supplied by the meat packing company[a]

Ingredients (Item 13)	Weight lb.	Ingredients %
90/10 Lean boneless beef	180	44.4
50/50 Choice beef trim	140	34.6
GSVP[b]	35	8.6
Water	50	12.4
Total	405	100.0

[a]East Tennessee Packing Company, Knoxville, Tennessee.

[b]GSVP--Griffith Structured Vegetable Protein: Series 125, Griffith Laboratories, Inc., Alsip, Illinois.

work began two weeks later. As needed, the 10-lb units were opened one at a time, and a test quantity was removed by count.

Preliminary Work

Preliminary trials were necessary in order to establish control techniques which simulated conventional materials handling. These techniques included (1) operation of the cooking equipment, (2) developing criteria for doneness, (3) portioning of the cooked patties, (4) establishing microwave reheating standards with respect to time and sample placement within the microwave oven, and (5) shearing portions of the cooked patties with the Instron, universal testing machine.

Control techniques for the use of cooking equipment centered on time:temperature relationships in order to fall within the ranges recommended by the manufacturers. In focus were cooking times being constant and cooking temperatures being variable for the pieces of commercial equipment. Observations were made during regular food production cycles of two institutions. The cooking of frozen, all meat patties by commercial equipment was noted for comparisons with the similar meat patty product and pieces of commercial equipment selected for use in the experimental study. From these observations and from the equipment manufacturers' recommendations, estimates for time and temperature were made for the three pieces of heating equipment prior to preliminary heating trials.

Patties from one experimental lot of soy-extended meat patties and patties shaped by hand from an all meat, lean, ground beef sample were cooked together by each piece of equipment as a preliminary procedure. Criteria for doneness and time:temperature coordinates then were established for cooking the meat patties for the first replication. Doneness was based on internal temperature end point (160 ± 5°F, 71 ± 1°C) for a medium well done state with uniform surface browning among treatments. In Table 2 the time:temperature coordinates are listed. These coordinates were acceptable for succeeding replications.

Equipment

Pieces of equipment used to cook the meat patties were the following: (1) grill (griddle), portable, electric Toastmaster model 7A4; (2) natural convection oven, General Electric model CN52 with damper closed; (3) forced-air convection oven, General Electric model CN90A, 10-rack unit with vent closed. This equipment was checked and found to maintain selected temperature settings, cycling approximately ± 25°F (± 14°C). The grill temperature was checked with a West Bend griddle meter model 3165. The temperature of the two ovens was checked with copper-constantan thermocouples attached to a Honeywell electronic 16-multipoint temperature recorder model 16.

The use of equipment for applying treatments was characteristic of its commercial use. Each piece of equipment was preheated approximately 30 min, a minimum of two cycles, before cooking was initiated. Baking positions used were the center of the top deck of the natural convection oven and the middle rack of the forced-air convection oven. Grill positions used were two successive patterns of 12 patties arranged 4 X 3 to uniformly cover the grill surface. The handling techniques for the food product were similar before and after treatments.

Table 2--Coordinates established for treatment effects through operation of commercial equipment to cook frozen, soy-extended meat patties

Treatment	Operating temperature °F	°C	Average cook. time min	Internal temperature °F	°C	Special controls
Grill	350	177	9	160 ± 5	71 ± 1	Seasoned lightly with vegetable oil.
Bake/ natural convection	425	218	10	160 ± 5	71 ± 1	Damper closed; top deck; setting on high for top and bottom elements.
Bake/ forced-air convection	375	191	8	160 ± 5	71 ± 1	Fan on; vent closed; rack #6 center position.

A Taylor Bi-Therm pocket thermometer, model 6072-1, was used for determining doneness by internal end point temperature. The 5-in. long, 1/8 in. diameter probe was inserted horizontally into 3-5 patties randomly selected for placement. Thermometer calibration ranged from 0°-220°F with 2°F intervals.

The microwave oven used for reheating samples was a Raytheon Radarange Mark IV R&W 1060CY. A minimum of 10 min for preconditioning the oven's system was necessary before switching on the magnetron tube for the microwave cooking operation.

Bulk Weighing Techniques

Appropriate batch weights of the raw and cooked product were made to the nearest 1/4 oz on a Toledo Speedweight scale, model 3031, capacity 50 lb, for the calculation of cooking losses. Within 20 min before cooking, the required number of frozen meat patties was removed from a lot and weighed in a preweighed pan. Sample weights were calculated by differences from the preweighed pans for raw, cooked, total cooking losses, and drip. Evaporative loss was calculated as the difference between total loss and drip. For an oven cooked sample, the weight of drip was obtained after removal of the cooked patties from the baking pan. For a grill cooked sample, the accumulated drip was carefully scraped from the grill into the preweighed drip pan of the grill. Further details about weighing the raw and cooked batches are given in Appendix A.

Bulk Packing

The cooked patties were placed randomly in stacks of 6 X 4 in stainless steel half-size steam table pans, 12 X 10 X 4 in. Each sample of stacked, cooked patties was covered and refrigerated promptly.

Chill Storage

The bulk packed, cooked meat patties were stored in a Victory, 2-door, upright commercial refrigerator, model RA-2D-S, at 38 ± 5°F (4 ± 1°C). Patties needed for subsequent handling were removed after chilling approximately 24 hr. When each pan was uncovered, condensate which had formed under the lid was allowed to sprinkle over the stacks of patties within the pan.

Portioning Techniques

Portioning the cooked patties was a fundamental procedure in meeting the objectives (1) to serve comparable reheated portions from all three heat treatments at one time for sensory evaluation and (2) to measure moisture content and shear force on comparable portions of the same food. A special cutting tool was designed and crafted for portioning the meat (Fig. 2). The 3 1/2 in. diameter, 5-section tool cut a 3/4 in. center strip (diameter) and 4 quadrants of approximately equal size. The center strip of a cooked sample included effects of treatment on top and bottom surfaces as well as on the edge and in the center of the individual meat patty. The 4 quadrants of the cooked sample included effects of treatment on top and bottom surfaces, to the edge, and almost to the exact center of the individual patty.

Although the raw patties were round in shape, during cooking they acquired a more elliptical shape. This slight change in shape was used to advantage in the alignment of individual patties for cutting. Cutting was done so that the center strip was on the shorter diameter.

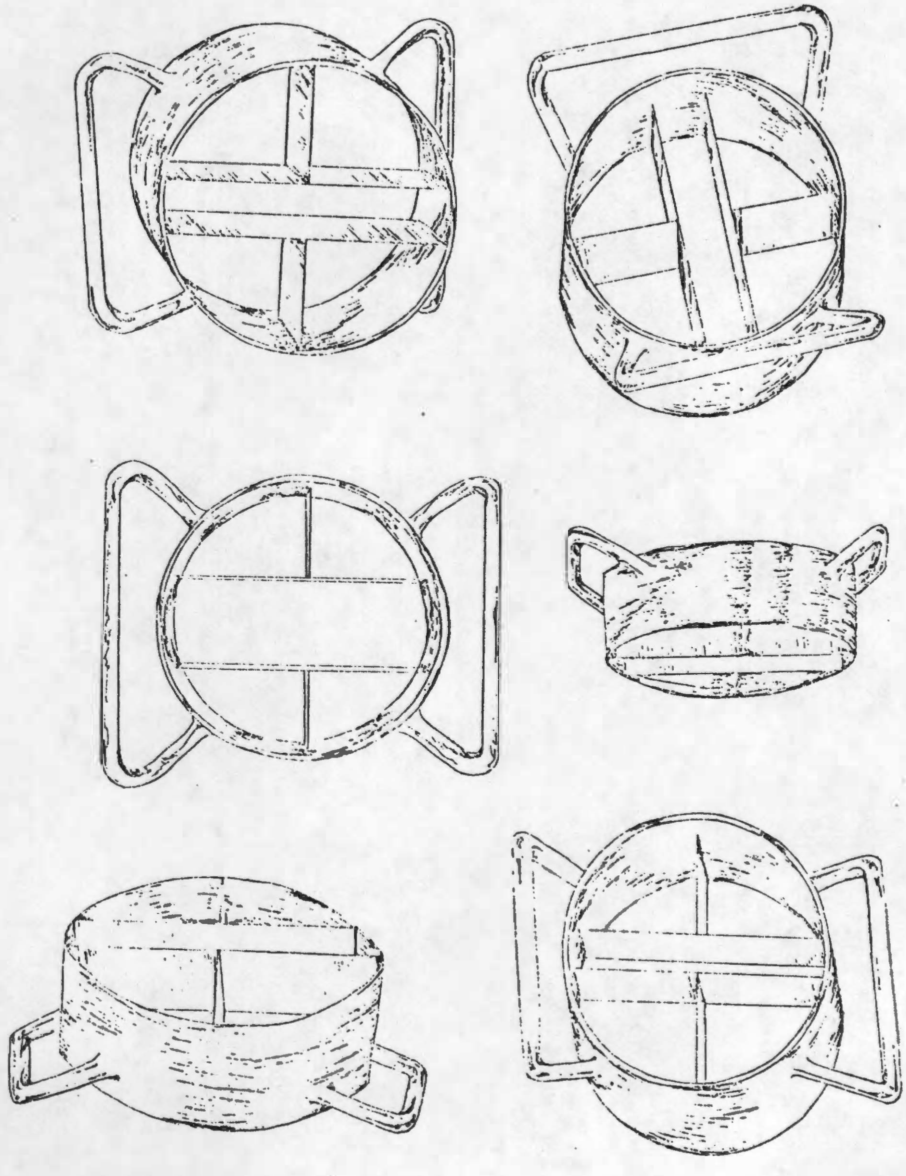


Fig. 2--Illustrations of the special cutting tool designed and crafted from stainless steel for this study.

Justifications for this decision were to achieve a uniformity of fit of the center strips for the shearing instrument and to allow the remaining portions to appear as large as possible for sensory evaluation.

After cutting 8 patties per treatment, the cut pieces were juxtaposed according to a specific plan for placement (Fig. 3). Twenty-four composite patties emerged for reheating. Plates with coded rims were used for organizing the composites. Surface characteristics of the meat resulting from treatment were preserved in the forming of the composites. The 5 cut pieces of each composite included 1 quadrant per treatment and 1 additional quadrant plus center strip for one treatment. The pieces of each composite patty were fitted snugly as a means of minimizing surfaces which might be affected during subsequent microwave reheating.

Microwave Reheating Technique

The microwave oven's capabilities were estimated from internal temperature of reheated patties arising from preliminary trials and from observed patterns of evaporation of measured pools of water. Both media were placed in suitable locations for plated samples in the study. Uneven scattering of microwaves during the reheating phase of the food handling system was considered probable. Accordingly, the composite patties were arranged by a predetermined pattern which designated the placement of pieces on the plates and a triad placement of plates within the microwave oven (Fig. 4). Further details of the technique for reheating composite patties are itemized in Appendix A.

From preliminary work, the microwave reheating time for a single, chilled, composite patty on a plate was found to be 30 sec. When two

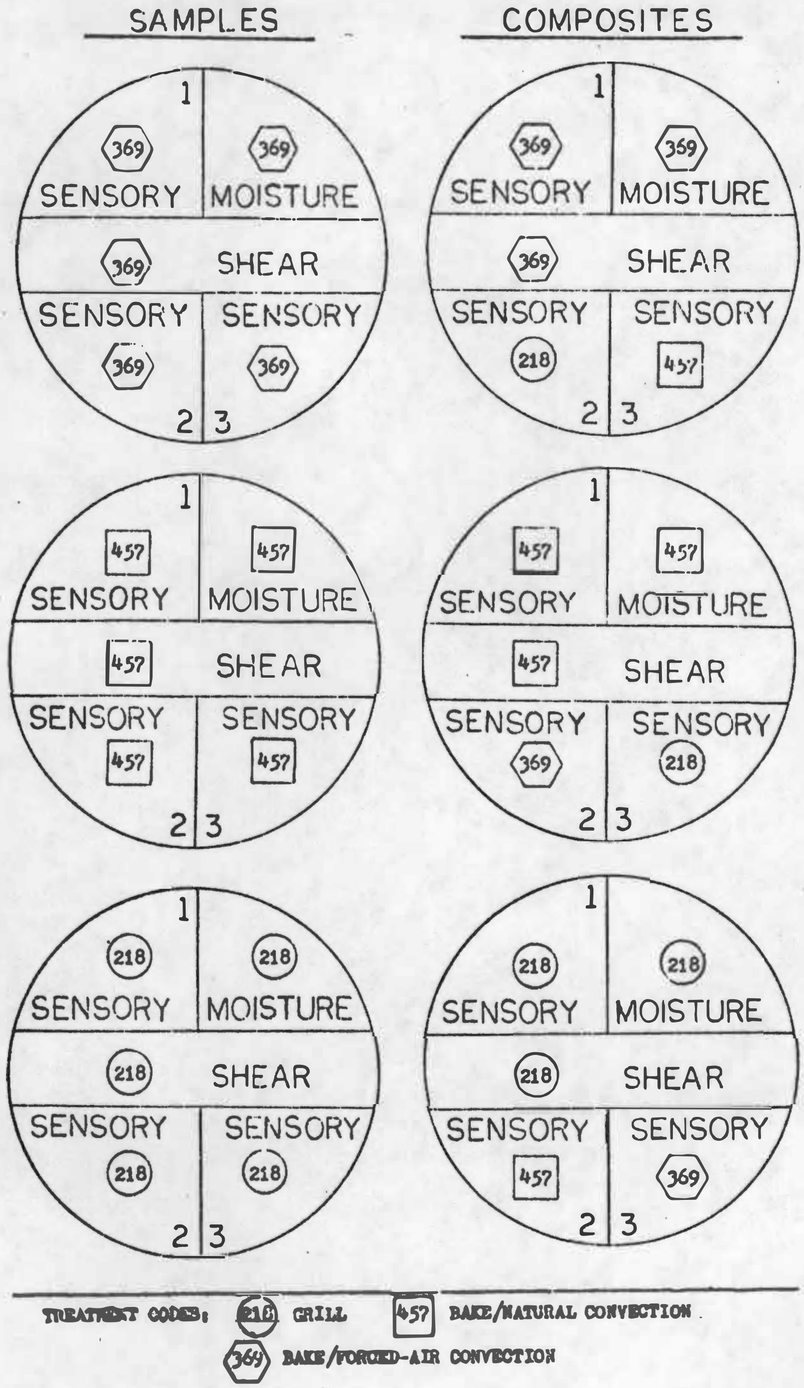
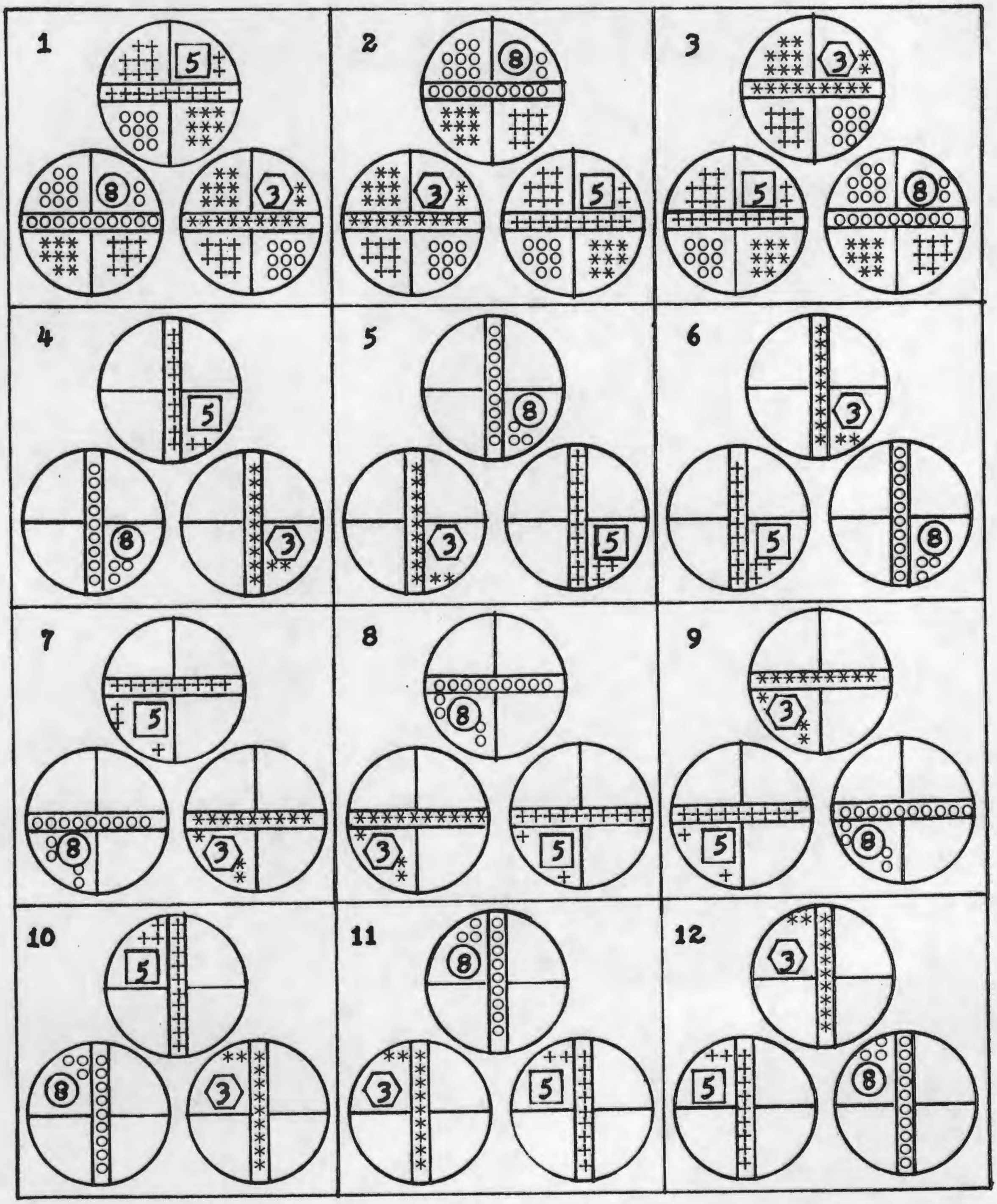


Fig. 3--Plan for portioning cooked samples, coded for treatment and for juxtaposing numbered quadrants to form composite meat patties.



TREATMENT CODES: (8) GRILL [5] BAKE/NATURAL CONVECTION

(3) BAKE/FORCED-AIR CONVECTION

Fig. 4--Pattern for composite rotations based on center strips and for composite triads for each microwave reheating cycle.

or three patties were being reheated, the time was increased about 3-5 sec to provide uniform heating. Calibrations on the timing device of the microwave oven were imprecise for less than 10-sec intervals. Therefore, the additional time approximated 1/3 to 1/2 of a 10-sec interval on the timing device.

Coding of Samples

The cooked patties were coded with 3-digit numbers for identification throughout the various handling stages per replication. A coding plan was essential not only for identifying treatment, but also for prescribing the location of portions within a composite and for rotating the composites through the microwave reheating pattern. Treatment codes were marked strategically on the plates used for reheating and serving. A numbering system was devised arbitrarily wherein one of the three digits was repeatedly used to identify treatment (Table 11, Appendix A). The key digits used were 8, Grill; 5, Bake, natural convection; and 3, Bake, forced-air convection. The coding system was not indicated to consumer panelists.

Disposition of Reheated Composite Patties

Immediately after microwave reheating, the two composite pieces designated for objective measurements were removed and placed in separately coded plastic bags. The enclosed portions were kept at room temperature until measurements were made.

The three remaining pieces of each composite patty were quadrants representing the three heat treatments. The coded portions were presented quickly to a consumer panelist who had the benefit of tasting hot samples.

Moisture and Moisture Retention Determination

Moisture determination of the composite patty portions began within an hour after collecting the last portions and proceeded by AOAC guidelines (AOAC, 1970) for vacuum drying to constant weight. Additional details for moisture determination are itemized in Appendix A.

Since the composite patties had increased surface areas due to the cutting, there existed an increased chance of moisture loss during microwave reheating. For comparison with the composite patties, three whole, cooked patties per treatment were selected from the chill stored quantity. These were positioned in the triad pattern and microwave reheated. The three patties then were subjected to the same procedure for moisture determination as described (Appendix A).

Moisture content of raw patties by lot was determined by the same procedure as for cooked patties. Four patties were withdrawn from each lot. These raw patties were taken one each from a 10-lb unit per carton.

Values for percent moisture retention were derived by the formula reported by Anderson and Lind (1975):

$$\%\text{Moisture Retention} = \%\text{Yield} \times \%\text{Moisture Cooked} \div \%\text{Moisture Raw}$$

Shear Force and Shear Force Index Determination

In preliminary work shear force values for meat tenderness reflected greater sensitivity when derived from the Kramer Shear Cell than when derived from the Warner-Bratzler Shear. The unique dimensions of the center strips contributed to the effectiveness of the Kramer Shear Cell. The recorder defined force-distance curves clearly for the composite center strips in the multiblade cell attachment.

The center strips from reheated, composite patties collected for shear force measurements were held enclosed for 4-6 hr at room temperature. Kramer's (1973) precautions with regard to the importance of consistency in the loading of the cell were considered. Cutting the center strips to about 2/3's length, approximately 6.5 cm, was necessary for fitting the strips in a single layer inside the Kramer Shear Cell. Two cut strips and their two resulting ends were fitted into the bottom of the cell perpendicular to the cell slots. The two trimmed ends were placed end-to-end and located as one of the outer strips. Additional details for the shearing procedure are itemized in Appendix A.

Shear data may be calculated as maximum force from peak height or as work measurement from area under the peak. Weight of the test cell load may be either standardized or indexed with the shearing force (Szczesniak et al., 1970; Szczesniak, 1973). In the present study each cell load of center strips was weighed before shearing, and shear force measurements were used for calculating an index of sample weight to maximum shear force (g/kg).

Maximum shear force of composite center strips was measured by the Instron, universal testing machine, with a 500 kg load cell and range 20. Measurements in the first replication (Lot A--Rep. 1 and Lot B--Rep. 1) were made on Instron Model 1130, tensile mode. Measurements in the second replication (Lot A--Rep. 2 and Lot B--Rep. 2) were made on Instron Model 1132, compression mode. The necessity of using two instruments resulted when the load cell of the first instrument jammed. In order to maximize uniformity between the two instruments, the same Kramer Shear Cell attachment was used, and gear settings were synchronized at Chart BX BY and Crosshead 26DX 26DY. These gear settings controlled speeds for charts at 100 mm/min and crossheads at 50 mm/min or 2:1.

Consumer Panel Evaluation

A consumer panel was used to evaluate specific sensory characteristics of the soy-extended meat patties. Appearance, flavor, tenderness, juiciness, overall acceptability, and preference ranking were evaluated to ascertain whether differences existed among treatments (Amerine et al., 1965; Doehlert, 1968; Abbott, 1973).

The panel members were recruited from the student body and the staff of the College of Home Economics, The University of Tennessee, Knoxville. Some of the students were "transients" who happened to be near the testing site at an opportune time and were persuaded to taste test "hamburger patties." Recruitment of most of the panelists included selective distribution of handbills to prospective participants and posting of handbills in areas of high student traffic in the building (Appendix B). Undergraduate students in a quantity food production class joined the consumer panel as an extension of their studies. Sensory evaluation was determined at 10:30 a.m. to 12:30 p.m. on each of the 4 days.

To obtain meaningful data from a consumer panel, the number of participants must be greater than for a trained panel (Kramer and Twigg, 1962; Amerine et al., 1965; ASTM, 1968). For each lot and replication, a minimum of 20 consumers was planned, and a maximum of 24 composite patties was prepared each time. For the four times of consumer participations, there was a total of 89 evaluations per treatment. Of these total evaluations, 76% were from individual participants, and 24% were from participants who volunteered more than once. Total participation was considered high because there was flexibility for participation within a 2-hr time range and because there was proximity to one's mid-day meal.

On arrival the consumer panelists were seated at counter top stations. Each station contained three printed items requiring the participant's attention. These items were (1) consent form, (2) directions for tasting, and (3) score card (Appendix B). The panelist was advised as to his/her role in the study. While he/she attended to the consent form and the directions, a composite meat patty was microwave reheated. Each panelist received a plate with coded portions of meat patties for sensory evaluation. Identification of treatments was not made known to the panelists until all sensory observations were completed. At that time a statement was publicly posted.

The score card designed for sensory evaluations included three observation categories. A 7-point scale was used for appearance and flavor, ranging 7--excellent to 1--extremely poor; and a 7-point scale also was used for tenderness and juiciness, ranging 7--very tender or juicy to 1--very tough or dry. Overall acceptability was judged by checking one of six terms, "like very much" to "dislike very much." These terms were subsequently assigned numerical values of 6 to 1. Preference was ascertained by ranking the code numbers _1_, _2_, or _3_.

Statistical Evaluation

The experimental design was a 3 X 2 X 2 for treatments, lots, and replications. Twenty-four patties per treatment replication were cooked to represent institutional batch sizes. Scores of quality attributes were reduced by analysis of variance for the several objective and subjective observations. Ranking of treatments was subjected to difference analysis (Larmond, 1970). Preference of treatments was indicated by each panelist's ranking the samples for first, second, or third choice. The procedure for analysis of the ranks required the assignment of numerical values. The series of three items was valued at .85 for first, 0 for second, and -.85 for third. Conversion of the ranks to the assigned values yielded numbers which were subjected to analysis of variance.

Coefficients of correlation were calculated among (1) scores for all sensory attributes, (2) mean scores for all objective measurements, and (3) daily mean scores for sensory and objective measurements. Stepwise multiple regressions were calculated for predicting effects on certain dependent variables (Kramer and Twigg, 1962; Sokal and Rohlf, 1969; Barr and Goodnight, 1972).

CHAPTER IV

RESULTS AND DISCUSSION

Soy-extended patties were cooked by typical commercial procedures using conventional equipment for grilling, baking by natural convection, and baking by forced-air convection. A chill/serve system for institutional food service was simulated.

Composite meat patties were formed from cooked samples to represent all three cooking methods for reheating and serving. From each composite patty comparable portions were removed for both objective and subjective assessments. Quality indicators were objectively evaluated as batch cooking losses, percent yield, percent moisture from which percent moisture retention was calculated, and shear force from which shear force index was calculated. Sensory attributes were evaluated by a consumer panel. Data were subjected to analysis of variance. Summaries of means for all assessments are presented in Tables 12 and 13, Appendix C; additional data are included also for predicting equations (Tables 14 to 16, Appendix D); and coefficients of correlation (Tables 17 to 19, Appendix E).

I. OBJECTIVE MEASUREMENTS

Analyses of variance for objective measurements except shear force index are presented in Table 3. Total cooking losses were affected ($P < 0.05$) by treatment, lot, and replication. Drip losses were affected significantly ($P < 0.01$) by treatment. Evaporative losses were affected

Table 3--Analysis of variance for batch cooking losses, yield, and moisture values of cooked meat patties

		MEAN SQUARES							
		Batch cooking losses				Moisture		Moisture retention	
Source of variation	d.f.	Total (oz)	Drip (oz)	Evap. (oz)	Yield (%)	Composite (%)	Whole (%)	Composite (%)	Whole (%)
Treatment	2	12.02*	17.86**	46.52***	21.15[a]	4.50*	2.35	37.64*	26.68
Lot	1	8.33*	.33	12.00**	9.01	22.85**	6.16	75.80*	148.54*
Replication	1	4.08*	.08	3.00*	8.60	.01	.03	6.22	7.81
Treatm't X Lot	2	.38	3.85*	4.70*	.32	.02	1.49	.59	5.33
Treatm't X Rep.	2	.82	.26	.20	.91	.27	4.36	2.35	13.27
Lot X Rep.	1	3.00	1.02	.52	7.36	.09	.06	8.23	4.23
Error	2	.41	.32	.07	2.59	.35	2.97	2.80	7.76
Total	11								
R^2 =		.99	.99	.99	.96	.42	.88	.98	.97

[a]$P < 0.06$

***$P < 0.001$

**$P < 0.01$

*$P < 0.05$

significantly ($P < 0.001$) by treatment, ($P < 0.01$) by lot, and ($P < 0.05$) by replication.

Predictable effects of the cooking methods on batch cooking losses were indicated (Table 4) by multiple comparisons of treatment means by the Student-Newman-Keuls (SNK) procedure (Sokal and Rohlf, 1969). The greatest total cooking losses (16 oz) and greatest evaporative losses (12 oz) occurred during the grill treatment as compared to total cooking losses and evaporative losses for the oven treatments--natural convection (13 oz and 5.6 oz) and forced-air convection (13 oz and 9 oz). Intensity of heat transfer to the food by conduction from the grill could be expected to cause rapid vaporization of moisture. The oven treatments were significantly different with respect to drip and evaporative losses. Forced-air convection with increased velocity of circulating air showed greater evaporation (9 oz vs 5.6 oz) from food surfaces and pooled drip than did natural convection with low velocity of circulating air.

An explanation of the significant effect ($P < 0.05$) of lot on total cooking losses was sought by comparing percent moisture of the raw meat patties by lot. Two lots of meat of the same formulation, manufactured on succeeding days, were used in the study. Differences (Table 5) between means of the two lots of raw patties were not significant ($P > 0.05$). Varying moisture levels of the uncooked patties probably contributed to the differential response of the lots with respect to some cooking and post-cooking parameters even though the two raw lots were not significantly different with respect to uncooked moisture levels.

Table 4--Treatment means of batch cooking losses, yield, and moisture values of cooked meat patties

Treatment	Batch cooking losses			Yield	Moisture		Moisture retention[a]	
	Total[f] oz	Drip oz	Evap. oz	%	Composite %	Whole %	Composite %	Whole %
Grill	16.25b	3.81c	12.44b	78.38	52.38c	53.32b	71.64d	72.96b
Bake/natural convection	13.19c	7.56b	5.63d	82.32e	54.12b	54.31b	77.76e	78.09b
Bake/forced-air convection	13.31c	4.00c	9.31c	82.39e	52.19c	52.81b	75.08c	76.06b

[a] %Moisture retention = %Yield X %Moisture cooked ÷ %Moisture raw

[bcd] Means within a column with different letters are significantly different at $P < 0.05$.

[e] $P < 0.01$

[f] Range of total cooking losses (oz): Grill, 15.00-18.00; Bake/natural convection, 12.00-14.50; Bake/forced-air convection, 12.00-16.00

Table 5--Comparison of means for moisture and moisture retention values of meat patties

Factors	N	Means $\overline{Y}_1$	$\overline{Y}_2$	Significance level
%Moisture of raw meat patties	4	Lot A[a] 60.18	Lot B[b] 54.56	NS
%Moisture of cooked composite patty quadrants	6	Lot A 54.28	Lot B 51.52	P < .01
%Moisture of cooked whole patties	6	Lot A 54.20	Lot B 52.76	NS
%Moisture retention of cooked composite patty quadrants	6	Lot A 72.31	Lot B 77.34	P < 0.05
%Moisture retention of cooked whole patties	6	Lot A 72.19	Lot B 79.23	P < 0.05
%Moisture of cooked patties	12	Composite 52.90	Whole 53.43	NS
%Moisture retention of cooked patties	12	Composite 74.83	Whole 75.71	NS
%Moisture of cooked patties	6	Lot A Composite 54.28	Lot A Whole 54.20	NS
%Moisture of cooked patties	6	Lot B Composite 51.52	Lot B Whole 52.76	NS

[a]June 7, 1976, day of manufacture of soy-extended meat patty product (Item 13) by East Tennessee Packing Company

[b]June 8, 1976, day of manufacture of soy-extended meat patty product (Item 13) by East Tennessee Packing Company

NS Not significant (P > 0.05)

Percent yield as a determinant of profitability in a food service system is a positive term for explaining to administrators the results of various treatments (Davenport and Meyer, 1970). In the present study an effect of treatment on percent yield approached significance ($P < 0.06$, Table 3). Meat patty yields with oven treatments were greater than with the grill treatment ($P < 0.01$, Table 4).

Data on the yield of meat patty products prepared for commercial and institutional use and/or the effect of method of commercial cooking on yield were not found in the literature. Increasing commercial and institutional reliance on meat patty products similar to the product used in this investigation was reported (Anon., 1972a; Cross et al., 1975; Smith et al., 1976). Formulations generally range 73-77% beef blends with 23-27% hydrated textured soy proteins.

Percent moisture of cooked meat patties was determined on pools of designated composite quadrants and on whole patties from the three treatments. For the composite patty quadrants, percent moisture was affected significantly ($P < 0.05$) by treatment and ($P < 0.01$) by lot as shown by analysis of variance (Table 3). Differences between lots were shown to be highly ($P < 0.001$) significant for percent moisture of the composite quadrants (Table 5). For the cooked whole patties, percent moisture was not affected significantly ($P > 0.05$) by either treatment or lot (Table 3). Means for percent moisture of the composite quadrants and the whole meat patties did not differ significantly (Table 5) between lots A and B.

The significant effect of lot on percent moisture of the composite quadrants may stem from the tendency toward different moisture levels in the two raw lots. The significant effect of treatment on percent moisture of composite quadrants may be examined for a relationship with the effect of treatment on drip loss and evaporative loss, inversely related variables. Natural convection baking resulted in greatest amount of drip loss (7.6 oz vs 3.8 oz or 4.0 oz), least amount of evaporative loss (5.6 oz vs 12.4 oz or 9.3 oz), and greatest amount of percent moisture (54.12% vs 52.38% or 52.19%) of composite quadrants. These parameters were all significant ($P < 0.05$). Although percent moisture (54.31%) of the whole meat patties was greatest for the natural convection baking treatment, the differences in percent moisture of whole meat patties were not significant ($P > 0.05$) among treatments. The patties baked by natural convection had the highest percent moisture, the least evaporation, and the most accumulated drip.

Similar comparisons for drip and evaporative loss with percent moisture of composite or whole meat patties are not as apparent for the grill and forced-air convection treatments. Evidently, the portioning and reheating of the composite patties magnified the effects of treatment and lot on the percent moisture of the composite quadrants.

Analysis of variance (Table 3, page 48) indicated significant effects ($P < 0.05$) of treatment and lot on percent moisture retention of the composite meat patties and significant effect ($P < 0.05$) of lot on percent moisture retention of whole meat patties. Comparison of treatment means (Table 4) showed significant differences among all three treatments for percent moisture retention by quadrants in composite patties. For meat patties cooked by natural convection where drip pooled around the samples, drip loss was greatest and evaporative loss was least. Natural convection treatment resulted in the highest percent moisture retention of the composite patty quadrants ($P < 0.01$). For meat patties cooked by grilling, drip was least, evaporative loss was greatest, and percent moisture retention for the composite patty quadrants was least ($P < 0.05$).

Percent yield and percent retentions of moisture and fat were means of expressing treatment effects used by Anderson and Lind (1975). Wolf (1970) assumed that good moisture retention and limited fat retention were benefits of textured soy protein (TSP) additions to meat patty formulations. Anderson and Lind (1975) accepted this premise and compared all beef patties to patties formulated to contain 25% hydrated TSP incorporated in beef blends of four fat levels. Their results indicated increased yield, increased moisture retention, and decreased fat retention in TSP-extended patties compared with all beef patties regardless of the fat content of the TSP-extended patties.

Results of the shearing of diameter strips from composite patties were reported as an index of grams of sample to kilograms of maximum force by the Instron, universal testing machine; therefore, the index varied directly rather than inversely with tenderness. Maximum force was calculated from the highest peak of the sample curve recorded by the Instron set on Range 20. Analysis of variance (Table 6) and means (Table 7) indicated a significantly higher ($P < 0.05$) shear force index for Lot A than for Lot B. Treatment effects within lots were similar. This evaluation concurred with results of the t-test (Table 5) for the effect of lot on percent moisture. Both shear force index and percent moisture values were higher for Lot A than for Lot B in samples taken from composite patties.

Table 6--Analysis of variance for shear force index as calculated from g/kg of sample to maximum shear force using the Kramer Shear Cell attachment to the Instron, universal testing machine

Source of variation	d.f.	Mean squares
Treatment	2	.0001
Lot	1	.0117*
Replication	1	.0000
Treatment X Lot	2	.0005
Treatment X Replication	2	.0003
Lot X Replication	1	.0002
Error	2	.0011
Total	11	
R^2 =		.93

*P < 0.05

Table 7--Comparison between lot means for shear force index

Treatments	Lots A	Lots B
Grill	.39a	.30b
Bake/natural convection	.38a	.33b
Bake/forced-air convection	.39a	.33b

[ab]Means within a row or column with different letters are significantly different at P < 0.05.

The composite strips presumably permitted instrumental detection of meat patty characteristics, especially surfaces, as a result of treatment effects on tenderness. However, treatment did not affect shear force index significantly (Table 6, Table 7). Possibly the technique for holding the reheated strips before shearing fostered moisture equilibration from condensate thus modifying the apparent effect of treatment.

The Kramer Shear Cell as an instrument for measuring meat tenderness was used by Bailey et al. (1962) on multiple grades of beef loin and round steaks and by Cross et al. (1976) on multiple grades of ground beef patties. Not only did both groups find an effect of grade on tenderness, but both reported correlations between sensory scores for tenderness and shear force. The workers used standard sample weights whereas it was considered more important in the present study to retain the crusts of the entire strip and to report the results as an index of sample weight to shear force.

The weights of test cell loads were comparable by treatment but differed by lot. The effects of lot on shear force indexes as well as the lack of effect of treatment are shown also in the force-distance curves (Fig. 5). Stepwise regression equations presented in Table 14, Appendix D, indicate significant effects ($P < 0.001$) of percent moisture and lot on shear force index.

II. SENSORY ATTRIBUTES MEASUREMENTS

Meat patties from two lots and in two replications per lot were scored by a consumer panel for sensory qualities as affected by the three

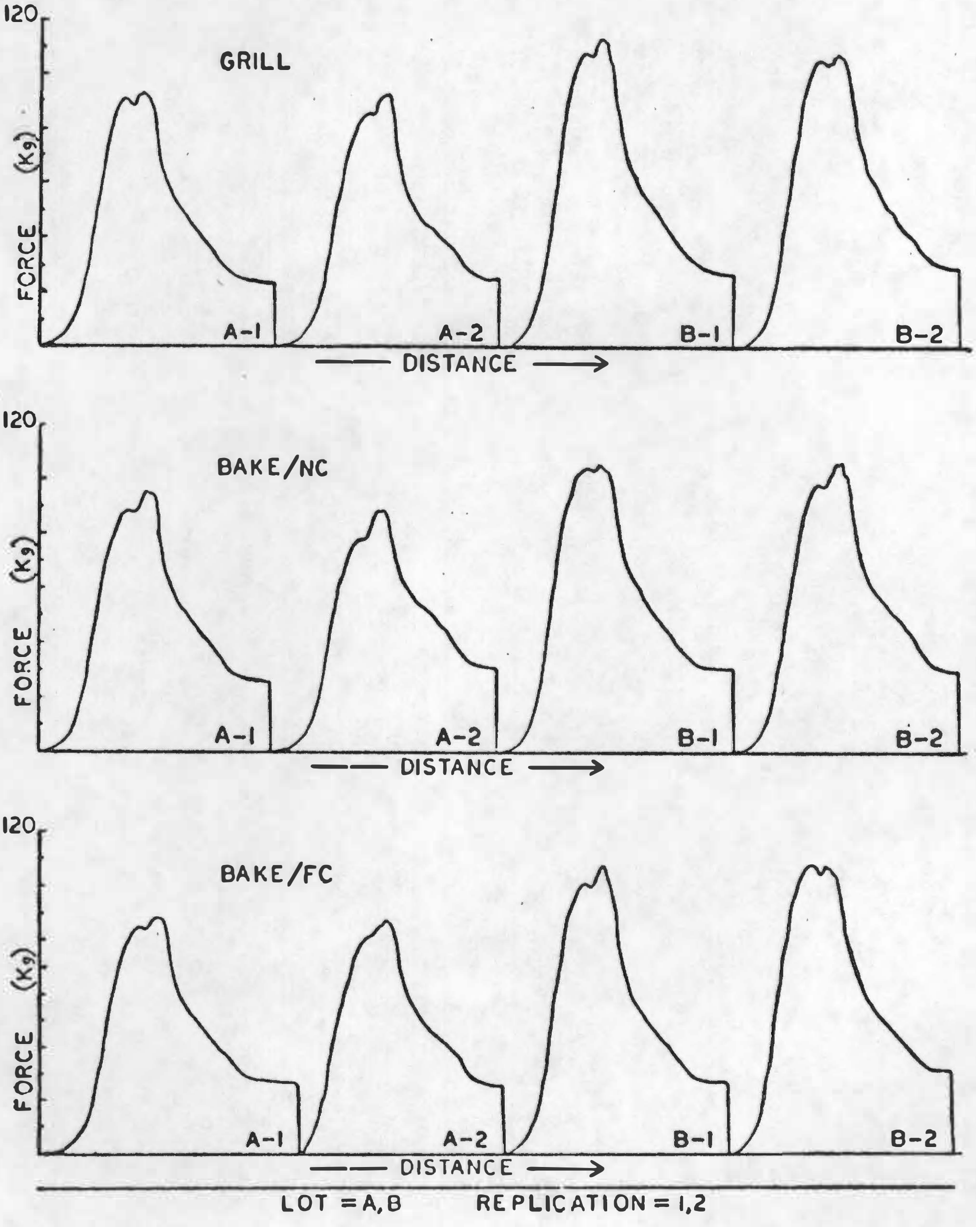


Fig. 5--Effect of treatment on force/distance curves of center strip portions of microwave reheated composite patties sheared in Kramer Shear Cell attachment to the Instron, universal testing machine. Each curve representative of at least 3 curves per lot and replication.

cooking treatments. Each attribute--appearance, flavor, tenderness, and juiciness--was scored by a 7-point palatability scale. Overall acceptability was scored by a 6-point hedonic scale with assigned values. Preference was scored by ranking treatments for first, second, or third choice (Score Card, Appendix B). Samples from each treatment were assessed for the assigned categories of quality attributes by 89 total observations from 68 individual panel members.

Results of the analyses of variance of scores for sensory attributes are shown in Table 8. Treatment affected the four quality characteristics--appearance at $P < 0.01$ and flavor, tenderness, and juiciness at $P < 0.05$. Replication affected ($P < 0.05$) both appearance and flavor scores. Mean squares for the inclusive terms, overall acceptability and rank, indicated no significant effect from any source of variation included in the model.

Meat patties baked by forced-air convection were preferred for appearance ($P < 0.01$) and flavor ($P < 0.05$, Table 9). Meat patties baked by natural convection, where drip loss pools around the sample, were more juicy than grilled patties ($P < 0.05$) but similar in juiciness to patties baked by forced-air convection ($P < 0.05$).

Flavor deterioration of meat under conditions similar to the present study was described as "warmed-over flavor" (WOF) when cooked, chilled beef was reheated (Sato et al., 1973). However, inhibition of WOF was achieved among possible treatments by adding textured soy proteins to ground meat products. The TSP additives reportedly provided a system for browning reactions which contributed to inhibition of WOF and, subsequently, extended the refrigerated storage time of the cooked meat.

Table 8--Analysis of variance for hedonic scores and for preference ranking scores of sensory attributes of cooked meat patties

Source of variation	d.f.	Mean Square: Appearance	Flavor	Tenderness	Juiciness	Overall acceptability	Rank
Treatment	2	5.85**	4.15*	3.95*	5.34*	1.76	.55
Lot	1	.86	.09	2.25	.11	.58	.00
Replication	1	5.85*	5.58*	.22	3.29	1.99	.00
Treatm't X Lot	2	.10	.76	.18	2.25	.70	.13
Treatm't X Rep.	2	.07	.60	2.54	3.58	.35	.69
Lot X Rep.	1	.10	.02	.65	.00	.35	.00
Error	257	1.19	1.18	1.34	1.43	1.66	.49
Total	266						
R^2 =		.06	.05	.05	.06	.02	.02

**P < 0.01

*P < 0.05

Table 9--Comparison of treatment means for sensory attributes of cooked meat patties

Treatment	Appearance[a]	Flavor[a]	Tenderness[b]	Juiciness[b]	Overall accept-ability[c]	Rank[d]
Grill	4.8f	4.6f	4.8e	4.9f	4.2e	-.04e
Bake/natural convection	4.9f	4.7f	5.3e	5.3e	4.3e	-.05e
Bake/forced-air convection	5.3e	5.0e	5.2e	5.1ef	4.5e	.09e

[a]Range 7--excellent to 1--extremely poor

[b]Range 7--very tender or juicy to 1--very tough or dry

[c]Range 6--like very much to 1--dislike very much

[d]Range first = .85; second = 0; third = .85

[ef]Means within a column with different letters are significantly different at $P < 0.05$.

The effect of replication on mean scores for appearance and flavor was tested by t-test for comparison of two means (Table 10). For both of these sensory characteristics, mean scores were higher for Replication 1 than for Replication 2. An explanation for these differences may be related to differences in moisture levels, although not significant, of the two raw lots which subsequently may have influenced rates of browning.

The importance of browning reactions which occur with meat proteins and which may occur within a system of proteins and sugars supplied by TSP might be viewed as contributing to the present differences in flavor and appearance among treatments. Possibly, cooking by forced-air convection increased the level of components resulting from browning reactions attributable to TSP. Although flavor was not described as WOF, the panelists obviously detected significant differences, preferring the flavor for patties baked by forced-air convection. Furthermore, the appearance of the patties cooked by forced-air convection could be described as more uniformly brown than the patties cooked by grill or natural convection. The appearance of grilled patties was medium brown with darker surface streaks. The appearance of patties baked by natural convection was a somewhat lighter brown than either of the other treatments presumably because of least surface drying during cooking.

The analyses of variance for overall acceptability scores and for preference by rank showed that neither of these attributes was significantly affected by the sources of variation. In order to predict overall acceptability, a stepwise multiple regression was calculated with scores for the four distinct sensory characteristics included in the model. The results (Table 15, Appendix D) indicated that flavor

Table 10--Comparisons of means by t-test for effect of replication on the sensory attributes of appearance and flavor

	Replications		
Sensory attributes	$\bar{Y}_1$ (n = 41)	$\bar{Y}_2$ (n = 48)	Significance of t-value
Appearance	5.1	4.8	P < 0.001
Flavor	4.9	4.7	P < 0.001

(P < 0.001), tenderness (P < 0.001), and appearance (P < 0.05) were important factors in establishing overall acceptability. Juiciness contributed little to the prediction (ΔR^2 = .0103).

Panelists generally preferred the patties cooked by forced-air convection treatment because of its effect on quality characteristics of appearance and flavor. Tenderness scores were not significantly different among treatments, yet the characteristic of tenderness was a significant predictor of overall acceptability. Juiciness scores were not significantly different between the two oven-cooking treatments. Therefore, for the characteristics contributing to overall acceptability, those scored highest tend to be for the forced-air convection treatment.

Consumer preference for a commercial method of cooking was anticipated as a result of ranking the cooked meat patties. However, no significant effects of treatment or other sources were found for the ranking by analysis of variance.

Coefficients of correlation among the variables shown in Tables 17, 18, and 19, Appendix E, were calculated. Low, but significant, "r" values existed among sensory attributes (Table 17). The highest correlation ($r = .65$, $P < 0.001$) existed between flavor and overall acceptability. This relationship was predicted by the stepwise multiple regression procedure. Scores for rank, a consumer's first, second, or third choice, correlated highly ($r = .63$, $P < 0.001$) with scores for overall acceptability. All correlations among specific quality attributes were significant at either $P < 0.01$ or $P < 0.05$.

The observations for nonsensory dependent variables were pooled data for each treatment by day where day represented lot and replication. Each of the three treatments was represented by four daily means for a total of 12 observations. Significant correlations existed among the variables representing cooking losses (Table 18, Appendix E). In general, high correlations existed among the variables which indicated an influence of moisture on yield and shear force values.

Sensory data were reduced to 12 daily means for correlation with objective data (Table 19, Appendix E). Recommendations for 50-100 observations (Kapsalis et al., 1973) were satisfied by the original number of sensory scores. The values for "r" showed correlations of moderate magnitude but few with significance ($P < 0.05$). With "n" being reduced in the study, the limited number of observations reduced the sensitivity of the coefficients of correlation.

Since correlations between subjective and objective measurements may lead to unwarranted conclusions (Szczesniak, 1968; Rhodes et al., 1972; Kapsalis et al., 1973; Noble, 1975), the experimentor planned for predictive information from the correlations. The plan for contributing to the sensitivity among correlations led to the design of the cutting tool. Portions of single meat patties contributed to both methods of measurement. The intention at least surmounted a limitation expressed by Kapsalis et al. (1973):

> Since both instrumental and sensory measurements are generally destructive in nature, it is not possible to perform the two types of evaluation on exactly the same sample.

The sensory panelists were assumed to be accurate in their interpretations of tenderness and juiciness although their responses were spontaneous and without benefit of training. Predicting equations suggested that tenderness and juiciness were mutually predictive sensory attributes in this study (Table 16, Appendix D). The shear force index values and percent moisture retention values gave important clues to the effect of cooking treatment. Greater sensitivity in correlation between subjective and objective measurements would have demanded texture profiling methodology, a level of precision exceeding consumer panel capability (Szczesniak, 1968; Kapsalis et al., 1973).

Selected aspects of the present study may be compared to selected aspects of reported studies for similarities with respect to food material, equipment, procedures, and sensory panels used for investigations of food quality characteristics. The food material subjected to treatment was within a range of formulation of extended meat patty products having wide commercial use (Anon., 1972a; Cross et al., 1975). A few reports were available on palatability traits of comparable products. Generally, palatability traits described for soy-extended meat patties were appearance, odor, flavor, tenderness, juiciness, and overall acceptability; comparisons were with palatability traits of soy-extended beef patties when hydrated TSP ranged 20-25% by weight and when fat ranged 20-30% by weight. All beef patties tended to score higher for flavor and appearance when compared with soy-extended patties, but differences were not always statistically significant. Differences in tenderness scores between the soy-extended and the all beef patties revealed the soy-extended patties to be significantly more tender (Huffman and Powell, 1970; Judge et al., 1974; Drake et al., 1975; Cross et al., 1975; Smith et al., 1976).

Results of the present study agreed in general with reports indicating that flavor, appearance, and tenderness are important contributors to overall sensory acceptance of soy-extended meat patties. Perception of tenderness was related to that of juiciness (Table 16, Appendix D). Unlike flavor and appearance, tenderness was not perceived to be different among samples as a result of method of cooking (Table 9, page 60).

Sensory panels of varying expertise were reported for the sensory assessments of meat patty products. Trained judges gave descriptive ratings when the experiments required development of standards for formulation (Smith et al., 1976). Consumer panels of varying sizes from 18-52 individual members and 52 families provided bases for marketing strategy and for sensory acceptance of soy-extended meat patty products among certain socio-economic strata (Cross et al., 1975; Twigg et al., 1977).

The effects of the conditions of the chill/serve system on food quality were not evaluated for change over time, over temperature, or with packaging method. With certain conditions comparable to the present study, quality changes have been reported for cooked meat under refrigeration. Flavor deterioration as a quality indicator was evaluated over time for effects of air head space in vacuum packages held at 3°C (38°F; Jakobsson and Bengtsson, 1972). Flavor deteriorated for the meat after 1 day with 9 ml head space and after 2 weeks with 0.5 ml head space. Of additional importance to the present investigation was a comparison of reheating the stored food by both microwave and convection oven methods. No noticeable quality differences were claimed for either reheating method.

While the use of commercial equipment comprised the experimental treatment effect in the present study, such use has not been the focus of studies examining quality characteristics of soy-extended meat patties. Cooking treatments reported for preparing meat patties for either trained or consumer panels and for measuring cooking losses or yields generally were for "home-type" fry pans or griddles and oven broilers. Anderson and Lind (1975) claimed use of a gas-fired convection oven of a brand known to be available for commercial use. Judge et al. (1974) used a gas-fired conveyor broiler which might be similar to ones in fast-food services. Details of equipment used for treatment effects were too limited for further comparisons.

The preceding results of investigation, discussion of findings, and comparisons with the literature furnish meaningful data to the food service administrator for developing management decisions about controlling food quality in the system. Pertinent findings are iterated below.

III. CONCLUSIONS

Quality assessment of meat patties cooked by three commercial methods, chill stored, and microwave reheated revealed the following information. Total cooking losses ($P < 0.05$) and percent yield ($P < 0.06$)

of meat patties were affected by heat treatments. Oven-cooking methods by natural convection and by forced-air convection contributed less to changes associated with moisture removal than did the grill treatment.

Shear force index as an indicator of tenderness was not affected by the three treatments but was affected ($P < 0.05$) by the two lots. This effect was probably related to moisture content of the raw lots, but the explanation is unclear.

Cooking treatments significantly affected sensory panel scores for appearance ($P < 0.01$) and for flavor, tenderness, and juiciness ($P < 0.05$). Of these four attributes, flavor and tenderness contributed most to the prediction of overall acceptability, followed by appearance. Tenderness scores were not affected significantly ($P > 0.05$) by a specific treatment. Panel scores for flavor and appearance clearly indicated the preference for meat patties baked by forced-air convection.

Panel scores for juiciness indicated that meat patties baked by forced-air convection were not significantly ($P > 0.05$) more juicy than patties cooked by either of the other two methods. However, with respect to juiciness, patties cooked by grilling and baking by natural convection were significantly different from each other ($P < 0.05$).

Consumer preference for any one of the three cooking treatments was not indicated by scores for overall acceptability or by ranking for first, second, and third choice when these scores were reduced by analysis of variance.

Indications of consumer preference for baking by forced-air convection treatment were found by comparing data in three analyses:

1. analysis of variance of the effect of treatment on appearance

($P < 0.01$) and on flavor and tenderness ($P < 0.05$);

2. stepwise multiple regression for predicting effects of flavor and tenderness ($P < 0.001$) and appearance ($P < 0.05$) on overall acceptability;

3. multiple comparisons of treatment means which revealed significantly higher scores ($P < 0.05$) for the appearance and flavor of meat patties baked by forced-air convection over meat patties grilled or baked by natural convection.

IV. IMPLICATIONS FOR FURTHER STUDY

Further investigations of food quality for food prepared in volume may be based on this study. Implications for research include concepts of equipment use and monitoring for control of yield and palatability.

The same model for investigation could be directed toward adjustments of the venting systems of the two kinds of ovens. Operating the ovens with vents or dampers open should affect cooking losses and possibly moisture retention by increasing evaporative losses and decreasing drip from potential condensate.

Energy appraisals for operating the various pieces of commercial equipment would be important data to combine with the present data in making operational decisions for equipment allocation.

Measuring time and motion requirements for the selected combination of product-to-equipment could form bases for productivity index, food quality control, employee scheduling, and employee training.

Comparisons of effects of freezing and refrigeration would add further information about moisture retention and palatability factors of foods held by low temperature storage when there is separation of the preparation and service functions.

Development of food quality accounting systems based on longitudinal data of percent yield and palatability indicators is needed so that rapid adjustments may be made in an operational setting for predicted quality.

Also recommended for further study is the concept of moisture retention in commercially prepared foods designed for microwave reheating. Moisture retention was significantly affected by cooking treatments in the present study. Palatability factors are largely moisture dependent in microwave-reheated foods (Anon., 1972b).

Future studies with soy-extended meat patties using a consumer panel for sensory assessment might include the option of adding salt during evaluation. Flavor and overall acceptability may be enhanced for the panelist who prefers salt and who controls the addition personally (Drake et al., 1974).

Management decisions for food quality control depend on the use of discrete criteria which describe anticipated characteristics of food quality. Characteristics such as cooking losses or cooking yields, percent moisture retention, texture, and specific sensory attributes are measurable entities. Data on some of these characteristics offer meaningful information for their control in a food service system.

CHAPTER V

SUMMARY

Awareness of the need for food quality standards as management resources in modern food service systems was the impetus to the research study. Treatment effects on qualities of food were investigated using commercial equipment for the preparation of soy-extended meat patties, a standardized product having wide commercial use. Two lots of frozen patties were cooked in 24 portion batches by grilling, baking by natural convection, and baking by forced-air convection. The cooked meat patties were bulk stored and microwave reheated to simulate a chill/serve institutional food service system. Meat patties were specially portioned to combine treatment effects in the microwave reheating and serving to consumer panelists.

Quality of food as affected by treatment in the preparation function of the food service system was assessed both objectively and subjectively. Measurements were made on 4 days representing two lots of meat patties and two replications of each lot. The methodology for the study supported a philosophical objective of bridging two points of view: (1) the food service administrator's need to have reliable bases for decision making and (2) the food scientist's interest in food qualities in response to treatment.

Objective assessments comprised the measuring of cooking losses, percent moisture, and shear force and the calculating of percent yield, percent moisture retention, and shear force index. Results indicated that yields and moisture retention of the meat patties were affected by cooking treatments. Oven methods gave greater yields and tended to give higher moisture retentions than did the grill method. Tenderness as expressed by shear force index was not significantly affected by treatment within the limitations of the study.

Subjective assessments were made by 89 consumer panelists scoring specified sensory attributes by hedonic scales and by ranking. Stepwise multiple regression analysis of scores for sensory attributes indicated the predicting influence of flavor, tenderness, and appearance on overall acceptability. No one commercial cooking treatment was preferred by the sensory panelists, although trends were detected for the preference of baking by forced-air convection. Appearance and flavor attributes resulting from this method were most highly rated among the three cooking treatments.

Food quality is a recognized goal of food systems administrators. A wise use of resources must occur for the assessment and maintenance of quality standards for food yields and acceptable palatability. Additional methods of inquiry were recommended for assessments of food quality.

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APPENDIXES

APPENDIX A

DETAILS OF SELECTED PROCEDURES

Bulk Weighing and Cooking

Placements of meat patties for weighing and cooking differed for ovens and grill in order to minimize handling of the food product. For an oven treatment, 24 frozen patties were arranged 4 X 6 on a preweighed 18 X 26 X 1 in. conventional bun pan for batch weighing and batch cooking. After baking in either oven, the patties with drip were allowed to sit at least 2 min in the bun pans before reweighing. In removing the cooked patties, each was handled with tongs and turned on edge to allow any drip to run back into the pan before determining weight of drip.

Frozen meat patties withdrawn for the grill treatment were placed in a preweighed, stainless steel, half-size steam table pan, 12 X 10 X 4 in. The half-size pan was used for deriving all batch weights by difference except drip. The batch was grilled in two groups of 4 X 3 patties. Drip was scraped from the grill surface after each group into a foil-lined preweighed drip pan under the grill surface. A grilled batch subsequently was stored in the same half-size pan.

Microwave Reheating

A maximum number of three plates holding composite patties was planned for reheating at any one time. A triad pattern for the plates and a progressive rotation of the placement of the composites (Fig. 4, page 40) facilitated the controlled location of samples for exposure to microwaves. The separate triad positions were designated for each composite based on the treatment of the composite center strip. With the identity of treatment effects, composite patties rotated completely through the triad positions within three reheating cycles. Following each triad position rotation, composite patties were given a sequence of right-angle, clock-wise rotations based on the placement of the composite center strips on the plates.

If fewer than three composites were reheated at any one time, a dummy plate holding about one teaspoon of water was located in the open position. Plates used in the study were 5-in diameter, white melamine.

Moisture Determination

The samples in each treatment pool were prepared with the grinder attachment to the Hobart mixer, model N50, using a grinder plate with 4.6 mm holes and gear setting 1. Triplicate samples of 5 ± 1g per treatment were weighed to the nearest mg on a top loading Mettler P120 balance. Drying was achieved within 12-16 hr in a vacuum oven at 61°C. After removal from the drying oven, samples were cooled in a desiccator for 15 to 30 min before weighing. Constant weight of samples was checked by redrying in the oven for 1 hr, cooling in the desiccator, and reweighing.

Preparations for Shearing

Meat patty surfaces resulting from treatment were consistently preserved in the handling of the composite pieces. These same surfaces were preserved in the preparation of center strips for shearing. Therefore, surface characteristics among treatments were more nearly preserved for measurements of treatment effects than if cooked patties were indiscriminately handled.

Before shearing any sample, the Kramer Shear Cell was rinsed in cool tap water and blotted dry on accessible surfaces. Between samples the cell was washed in warm, sudsy water, rinsed in cool tap water, and blotted dry on accessible surfaces. The rinsing of the cell before use and the method of drying contributed to uniformity in measurement conditions.

Coding of Samples

Table 11 -- Code numbers assigned to treatments per lot and replication

	Treatments		
Lot and replication	Grill (8)	Bake/ natural convection (5)	Bake/ forced-air convection (3)
A-1	801	562	324
B-1	782	451	930
A-2	684	059	137
B-2	899	574	362

APPENDIX B

GUIDELINES FOR SENSORY PANEL MEMBERS

HAMBURGER LOVERS ARISE!

JOIN THE CONSUMER TASTE PANEL AND EXPRESS YOUR PREFERENCE FOR A COMMERCIAL METHOD OF COOKING HAMBURGER PATTIES. QUALITY IS IMPORTANT.

BRING A FRIEND AND BE AMONG THE FIRST 20 CONSUMERS FOR A TASTING SESSION. CALL 5445 IF YOU NEED A SCHEDULE ADJUSTMENT TO BE ABLE TO PARTICIPATE.

SCHEDULE OF TASTING SESSIONS:

10:30 AM TO 12:30 PM ROOM 16 CHE BLDG.

JUNE 30 (W)	JULY 7 (W)
JULY 1 (R)	JULY 8 (R)

VOTE FOR A WINNER...

THE ALL-AMERICAN HAMBURGER... ☑

Anne L. Cook, Graduate Student
FSNFSA Ext. 5445

INFORMED CONSENT

The purpose of this investigation will be to study the effects of commercial cooking methods on the overall acceptability of burger patties. You will be given samples of burger patties to taste and to evaluate for appearance, flavor, juiciness, and texture. The burger patties have been treated in no way that will be harmful to you.

I, the undersigned, ______________________________, by my signature agree to participate in this project and understand that all results will be treated with strict confidence.

By my signature, I indicate that the research has been explained sufficiently to me in detail, that I may withdraw at any time, and that any questions that I may have about the project will be answered.

Signed: ________________________

Date: ________________ Witness: ________________________

DIRECTIONS FOR TASTING

1. THIS MORNING YOU WILL BE GIVEN THREE PORTIONS OF BURGER PATTIES TO EVALUATE. PLEASE READ THE SCORE CARD DIRECTIONS BEFORE YOU BEGIN TASTING.

2. IF YOU HAVE WRITTEN YOUR NAME ON THE SCORE CARD, PLEASE BLACKEN IT.

3. IF YOU HAVE ANY QUESTIONS DURING THE TASTING SESSION, RAISE YOUR HAND.

4. PLEASE DO NOT SMOKE OR TALK DURING THE TASTING SESSION.

5. PLEASE LEAVE YOUR SCORE CARD IN PLACE AT YOUR BOOTH WHEN YOU FINISH TASTING.

6. THANKS FOR COMING AND TASTING! AFTER ALL SESSIONS ARE COMPLETED I WILL POST INFORMATION ON HOW THE PATTIES WERE PREPARED BY COMMERCIAL PREPARATION METHODS. IF YOU WILL LEAVE YOUR TELEPHONE NUMBER, I WILL CALL YOU ABOUT THE INFORMATION BEING POSTED.

alc
6/28/76

GRADING SCALES FOR MEAT PATTY SAMPLES

No. ________ Date ____________________

I. Directions: Give full value for excellence of quality attributes. Do not use fractional points.

Scale for scoring appearance and flavor:

7--Excellent
6--Very good
5--Good
4--Fair
3--Poor
2--Very poor
1--Extremely poor

Scale for scoring tenderness and juiciness:

7--Very tender or juicy
6--Tender or juicy
5--Moderately tender or juicy
4--Neither tough nor tender, dry nor juicy
3--Moderately tough or dry
2--Tough or dry
1--Very tough or dry

Sample No.			
Appearance			
Flavor			
Tenderness			
Juiciness			

II. Directions: Consider the above factors together and evaluate each sample for over-all acceptability. In the chart below check the column opposite each sample which best represents your judgment for liking or disliking it.

Sample	Like very much	Like moderately	Like slightly	Neither like nor dislike	Dislike moderately	Dislike very much

III. Directions: Please rank the three samples according to your preference for 1st., 2nd., and 3rd.

_____ ______ # _____ ______ # _____ ______

Comments per any of the above grading scales:

APPENDIX C

SUMMARIES OF MEANS

Table 12--Means of objective measurements by treatment, lot, and replication

Treatment	Lot	Replication	Batch cooking losses			Yield	Moisture		Moisture retention		Shear force index
			Total	Drip	Evap.		Composite	Whole	Composite	Whole	
3	2	2	oz	oz	oz	%	%	%	%	%	g/kg
Grill	A	1	15.75	2.50	13.25	79.14	53.73	56.17	70.66	73.87	.3788
	A	2	18.00	3.25	14.75	76.32	53.93	53.25	68.39	67.53	.4029
	B	1	15.00	4.50	10.50	79.93	50.92	52.77	74.60	77.31	.3023
	B	2	16.25	5.00	11.25	78.11	50.93	51.09	72.91	73.14	.3058
Bake/ natural convection	A	1	13.25	8.25	5.00	82.57	55.56	53.17	76.23	72.95	.3773
	A	2	14.50	8.75	5.75	80.54	55.44	56.57	74.20	75.71	.3782
	B	1	13.00	7.25	5.75	82.67	52.14	53.59	79.00	81.20	.3311
	B	2	12.00	6.00	6.00	83.51	53.32	53.90	81.61	82.50	.3372
Bake/ forced-air convection	A	1	13.00	3.00	10.00	83.67	53.72	53.18	74.69	73.94	.4119
	A	2	16.00	4.00	12.00	78.74	53.27	52.83	69.70	69.12	.3610
	B	1	12.00	4.75	7.25	83.28	51.16	52.28	78.09	79.80	.3198
	B	2	12.25	4.25	8.00	83.88	50.62	52.94	77.82	81.39	.3392

Table 13--Means of sensory attributes by treatment, lot, and replication

Treatment (3)	Lot (2)	Rep. (2)	N (89)	Appearance[a] mean ±	SE	Flavor[a] mean ±	SE	Tenderness[a] mean ±	SE	Juiciness[a] mean ±	SE	Overall acceptability[b] mean ±	SE	Rank[c] mean ±	SE
Grill	A	1	20	5.00	.26	4.50	.25	4.95	.22	5.10	.36	4.15	.31	-.13	.17
	A	2	24	4.58	.21	4.46	.20	4.96	.25	4.92	.26	4.38	.25	.07	.15
	B	1	21	4.91	.19	4.91	.23	5.19	.27	5.10	.24	4.33	.31	-.00	.15
	B	2	24	4.75	.30	4.54	.23	4.33	.25	4.38	.28	4.04	.27	-.11	.17
Bake/ natural convection	A	1	20	4.95	.19	5.05	.22	5.40	.25	5.45	.25	4.30	.26	-.17	.15
	A	2	24	4.63	.23	4.46	.23	5.33	.21	5.42	.20	4.21	.26	.00	.12
	B	1	21	5.05	.22	4.95	.23	4.86	.31	5.38	.28	4.48	.26	-.08	.17
	B	2	24	4.88	.18	4.58	.21	5.38	.18	5.21	.16	4.17	.21	.07	.09
Bake/ forced-air convection	A	1	20	5.35	.25	5.25	.32	5.50	.21	4.95	.25	4.85	.30	.30	.14
	A	2	24	5.08	.20	4.96	.22	5.04	.23	4.96	.28	4.42	.26	-.04	.16
	B	1	21	5.57	.19	5.00	.22	4.91	.32	4.91	.31	4.43	.31	.08	.14
	B	2	24	5.13	.29	4.92	.22	5.42	.18	5.58	.17	4.29	.29	.04	.16

[a]Based on 7-point scale

[b]Based on 6-point scale

[c]Based on assigned values: first = .85; second = 0; third = .85

SE Standard error of the mean

APPENDIX D

STEPWISE MULTIPLE REGRESSION MODELS

Table 14--Stepwise multiple regression models predicting moisture related effects on shear force index of cooked meat patties[a]

Intercept	%Moisture, composite patty quadrants	Drip	Evaporation	ΔR^2
-.5239	.0166**			.6145
-.6845	.0205***	-.0091**		.2234
-.6912	.0212***	-.0121*	-.0023	.0118

[a]n = 12

***P < 0.001

**P < 0.01

*P < 0.05

Table 15--Stepwise multiple regression model for predicting overall acceptability from scores for flavor, tenderness, appearance, and juiciness

Intercept	Flavor	Tenderness	Appearance	Juiciness	ΔR^2
.7074	.7567***				.4224
.0236	.6580***	.2267***			.0356
-.3913	.6046***	.2325***	.1287*		.0104
-.4083	.6046***	.2231***	.1253*	.0161	.0001

***P < 0.001

*P < 0.05

Table 16--Stepwise multiple regression models with selected effects which predict attributes of tenderness and juiciness

Tenderness

Intercept	Juiciness	Percent moisture composite patty	Treatment	ΔR^2
1.3711	.7383**			.4980
1.5209	.6524*		.1197	.0885
-.6225	.5544*	.0495	.1331	.0575

Intercept	Juiciness	Appearance	Flavor	ΔR^2
1.3711	.7283**			.4980
-.1540	.6931*		.3555	.0833
-.0163	.6825*	.0764	.4176	.0016

Juiciness

Intercept	Tenderness	Percent moisture retention composite patty	Total cooking losses	ΔR^2
1.6360	.6838**			.4980
.9446	.6859*	.0125		.0212
-2.8068	.7325*	.0424	.0719	.0219

Intercept	Tenderness	Appearance	Flavor	ΔR^2
1.6360	.6838**			.4980
2.5174	.7101*	-.2036		.0308
2.5306	.7224*	-.1629	-.0581	.0008

**$P < 0.01$

*$P < 0.05$

APPENDIX E

COEFFICIENTS OF CORRELATION TABLES

Table 17--Coefficients of correlation among sensory attributes[a] of cooked meat patties

	Flavor	Tenderness	Juiciness	Overall acceptability	Rank
Appearance	.39***	.12*	.26***	.34***	.21***
Flavor	--	.41***	.31***	.65***	.48***
Tenderness		--	.59***	.44***	.35***
Juiciness			--	.32***	.30***
Overall acceptability				--	.63***

[a] n = 267

***P < 0.001

**P < 0.01

*P < 0.05

Table 18--Coefficients of correlation among means of objective measurements on cooked meat patties[a]

	Drip loss	Evap. loss	% Yield	%Moisture composite patty quadrants	%Moisture whole Patties	%Moisture retention composite patty quadrants	%Moisture retention whole patties	Shear force index
Total cooking loss	-.35	.81***	-.99***	.15	.03	-.99***	-.83**	.23
Drip loss	--	-.83**	.30	.36	.21	.30	.30	-.15
Evaporative loss		--	-.77**	-.13	-.12	-.77**	-.68*	.23
%Yield			--	-.10	-.02	.87**	.77**	-.11
%Moisture composite patty quadrants				--	.63*	-.10	-.44	.78**
%Moisture whole patties					--	-.01	.04	.48
%Moisture retention composite patty quadrants						--	.92***	-.11
%Moisture retention whole patties							--	-.55

[a]n = 12

***P < 0.001

**P < 0.01

*P < 0.05

Table 19--Coefficients of correlation between sensory attributes and objective measurements of cooked meat patties[a]

	Total cooking loss	Drip loss	Evap. loss	% Yield	%Moisture composite patty quadrants	%Moisture whole patties	%Moisture retention composite patty quadrants	%Moisture retention whole patties	Shear force index
Appearance	-.62*	-.29	-.19	.63*	-.35	-.28	.36	.35	-.12
Flavor	-.54	-.04	-.30	.61*	-.17	-.42	.36	.35	-.01
Tenderness	-.50	.16	-.40	.57*	.42	.38	.32	.22	.45
Juiciness	-.42	.44	-.52	.45	.34	.52	.36	.37	.25
Overall acceptability	-.25	-.25	.00	.36	.07	-.15	.03	-.07	.42
Rank	-.27	-.39	.08	.33	-.07	-.10	.13	.10	.32

[a]n = 12

*P < 0.05

VITA

Anne Looney Cook was born in Oneida, Tennessee, April 24, 1939. She was reared in Crossville, Tennessee, where she attended public schools and graduated from Cumberland County High School in 1956.

As a result of meaningful 4-H achievements, she was guided to educational goals in home economics. Educational milestones for Anne Looney Cook include degrees in home economics earned at The University of Tennessee, Knoxville--Bachelor of Science, 1960; Master of Science, 1963; and Doctor of Philosophy, 1977. A dietetic internship was completed at Vanderbilt University Hospital, Nashville, Tennessee, 1960-61.

Professional experiences include hospital dietetics in administrative, therapeutic, and nursing school teaching capacities; research and development in frozen foods manufacturing; academic appointments for nutrition, food science, and food systems administration courses; and consultant to school food service workshops in various Tennessee locations. Her present position is assistant professor of food science and food systems management in the School of Home Economics, The University of Tennessee at Martin.

Professional and honorary memberships include The American Dietetic Association as Registered Dietitian, Tennessee and District Dietetic Associations, The American Home Economics Association, The Society of Sigma Xi, Alpha Lambda Delta, Omicron Nu, and Phi Upsilon Omicron.

Anne Looney Cook is the daughter of C. Evans and Ruth Lanius Looney of Crossville, Tennessee. She is married to Norvel Harper Cook. The Cook family includes Christopher Collier (1962), William Wade (1964), and Mary Louisa (1971, deceased).