A STUDY OF THREE TYPES OF TRAY TRANSPORT EQUIPMENT FOR QUALITY AND TEMPERATURE CHANGES PRE- AND POST-TRANSPORT WITHIN A FOODSERVICE SYSTEM

A THESIS
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BY
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Introduction

The purpose of this study was to determine the difference in temperature and quality-holding capabilities among a heated/chilled cart and two types of pellet systems for patient tray transport in a hospital setting. Information on functions of transport equipment is limited to manufacturer specifications; review articles on equipment characteristics; and some research in the early 1960's on time-usage, holding temperature, and cost. The 1970's have seen advances in equipment which may indicate a need for additional information on the holding capabilities of transport equipment. Curiale (1971) and Flynn (1965) have identified equipment selection considerations and compared types of equipment. However, these writers presented no information regarding effectiveness in maintaining appropriate serving temperature and food quality. Laudenslager (1970) presented information on cost, holding temperature, and patient acceptance of an insulated tray system of meal transport. A heated/chilled cart was compared by Gee and Axelrod (May 1962, June 1962) to a pellet system with regard to time, temperature, personnel, and cost. These investigators indicated a need for further research of time/temperature relationship in the pellet system (Gee and

Axelrod, May 1962). Disposable and permanent serviceware have been studied with regard to temperature holding, cost, and patient acceptance (Heinemeyer, 1972; Mueller, 1969; Ward and Clark, 1972). Hartman (1969) has pointed out a need for research in all areas of foodservice. Unklesbay (1977) identified a need for further research regarding sensory indices of quality in alternate foodservice systems.

Statement of the Problem

The need to preserve maximum food quality and appropriate temperature of food during transport is basic to the objectives of a foodservice system. In support of these goals, the following aspects of the problem were investigated in this study:

1. What is the difference in temperature changes in hot foods transported on trays in heated/chilled carts versus two pellet systems within the Houston Veterans Administration Medical Center Foodservice System?

2. What is the difference in temperature changes in cold foods transported on trays in heated/chilled carts versus two pellet systems within the Houston Veterans Administration Medical Center Foodservice System?

3. What is the difference in hot food quality on trays transported in heated/chilled carts versus two

pellet systems, as measured by a panel of experts within the Houston Veterans Administration Medical Center Food-service System?

4. What is the difference in cold food quality on trays transorted in heated/chilled carts versus two pellet systems, as measured by a panel of experts within the Houston Veterans Administration Medical Center Food-service System?

Review of Literature

Factors Affecting Food Temperature and Quality During Transport

The factors affecting food temperature and quality consist of time, temperature, moisture, cooling rate, and type of food product. These factors are interdependent elements of on-premise control and have a significant role in the service temperature and quality of a food item.

The importance of time in relation to food quality and temperature cannot be overemphasized. Gee and Axelrod (June 1962) report time as the greatest single factor in temperature control. The basic premise involves the fact that all food reaches room temperature if held long enough (Ross, 1971). Food holding time should be minimal; and as time-lapses lengthen between service and consumption, other factors-- such as equipment-- must be adjusted to compensate (Ross, 1971). Inaccurate timing, as a cause of temperature and quality loss, was traced by Miller (1968) to the following faulty practices:

1. Haphazard adherence to the prescribed period required for proper execution of one or more particular steps of the procedure.
2. Unscheduled time lags between procedural steps, and resultant undesirable changes at interim stages during the production process.
3. Product changes resulting from too much or too little delay between the time the product is completely prepared and the time it is portioned for service.

Although these factors are factual, they cannot be considered inclusive of all possible causes of time-lapse between production and service. Time-lapses can be controlled by equipment selection and the degree of speed and coordination in the delivery system (Gee and Axelrod, June 1962; Peffers, 1963). The optimal time-lapse averages for some delivery systems have been defined. These are six minutes in plain carts and china, nine minutes for pellet systems, and undefined in heated/chilled carts when plugged into electrical receptacles (Peffers, 1963).

Temperature is the second major factor related to quality of food products. Hartman (1962) cited the lack of studies on food temperature acceptable to patients and the need for basic temperature standards. One subsequent study found acceptable food temperatures among a group of surgical patients to be 160° to 170°F. for vegetables and 150° to 160°F. for meats (Thompson and Johnson, 1963). Ross (1971) reported 140° and 150°F. to be the preferred eating temperature of hot foods. A study of holding temperatures found preferred serving temperatures to be 145° - 150°F. for soup and beverages; 140° - 145°F. for vegetables and entrees (Blaker, Newcome, and Ramsey, 1961). From these studies it appears that acceptable service temperatures of hot foods are between 140° and 170°F. To protect food from contamination and bacterial growth, hot food must be above 140°F and cold food below 45°F. (Stauffer, 1964). In order for food to be received by the patient at an acceptable temperature for both sanitation and palatability, the original temperature of the food must be higher to allow for cooling during holding (Ross, 1971). The required original temperature depends upon the holding time between service and consumption and the effectiveness of the holding equipment (Ross, 1971; Blaker et.al., 1961). Blaker, Newcome, and Ramsey (1961) found that the appropriate holding temperature of food could be predicted by determining the preferred eating temperature, the cooling rate for that food item, and the time-lapse from service to consumption. For example, tea-- with a preferred temperature of 149°F., and a lapse-time of 6 minutes--must be held at 160°F. according to the Blaker et.al., (1961) cooling rate curve. This study concluded that desirable holding temperatures may be readily calculated for any facility, given preferred eating temperature, food cooling rate, and time-lapse from service to consumption (Blaker et.al., 1961).

Moisture control affects quality of food during transport and may alter the nature, consistency, and texture of the food. Exposure to atmospheric conditions of humidity may cause dryness or sogginess in finished products (Miller, 1968). In transport, non-compartmented serviceware tends to cause blending of food moisture, flavor, and aroma, changing the quality of the food product (Laudenslager, 1970).

The cooling rate of food is dependent upon the food product, type of food container, and original food temperature (Ross, 1971). Two material medias of different temperatures transfer heat from the hot medium to the cool, so that temperatures equalize (Ross, 1971). Heat transfer through metals is more rapid than through china or glass; and the greater the temperature difference, the more rapid the heat transfer (Ross, 1971). The longer food is held before service, the more important it is to preheat containers for hot foods and chill cold food containers (Ross, 1971).

Heated Transport Equipment

Transport equipment can be divided into two basic types-- heated and unheated transport systems. Heated systems consist of a mobile unit (cart) which is heated and refrigerated by a self-contained system. Several types of heated carts are currently on the market. One type, the "tray-on-tray" system, consists of a heated/chilled cart in which a full size tray with cold items is fitted into the cold compartment and a half-size tray is held in the heated section (Flynn, 1965; Curiale, 1971; Peffers, 1963). At the point of service the hot food tray must be matched and set on the cold food tray (Flynn, 1965). A variation of this principle consists of two half trays, one hot and one cold that is matched and placed on a large tray at point of service (Curiale, 1971). Another system of heated/chilled transport involves a bulk delivery style to service area for hot and cold items (Bowman, 1972). These types of heated/chilled transport have the advantage of assembling hot and cold food at different times if desired (Peffers, 1963). The major disadvantage consists of loss of control of final assembly of trays and the added factor of requiring assembly of trays just prior to service (Peffers, 1963; Curiale, 1971; Flynn, 1965). There is a heated/chilled cart system which eliminates the disadvantage of assembly just prior to service. This system, the single-tray heated transport, consists of a cart in which hot and cold compartments are divided by a flexible gasket or by a solid divider with a slotted tray (Flynn, 1965; Bowman, 1972; Curiale, 1971; Jernigan, 1969; Peffers, 1963). Advantages of this type of cart are that the tray is assembled within the area of supervision and that proper temperatures are maintained while the cart is connected to the electrical supply (Peffers, 1963; Flynn, 1965; Jernigan, 1969). Disadvantages include the possible failure of the gasket to separate compartments appropriately and warping of slotted trays (Flynn, 1965).

Unheated Transport Systems

There is great variety in the type of unheated transport systems on the market. These nonmechanical means of temperature and quality maintenance consist of the following two basic classes of equipment: (a) permanent or disposable insulated serviceware, and (b) heated pellet systems (Jernigan, 1969). One insulated system uses both disposable and permanent serviceware. It consists of an insulated tray with disposable insets (Laudenslager, 1970).

In these trays, foods of the same temperatures are placed in compartments which, when the trays are stacked, form thermal columns (Laudenslager, 1970). When trays are assembled with foods of 160° to 195°F. this system can maintain optimal temperatures of meals for one to one and one-half hours (Laudenslager, 1970).

Heated pellet systems are composed of a heated disk or pellet, which holds a plate that is covered with either a metal or plastic top (Jernigan, 1969; Cabot, 1970; Peffers, 1963). Additional equipment needed to support a pellet system consists of plate warmers, pellet ovens, and insulated accessories for items outside the main plate (Jernigan, 1969). Plates are usually heated to 180°F., and pellets to 250°F. (Cabot, 1970). Advantages of this system include retention of heat while the patient is eating and compartively low cost (Jernigan, 1969). A disadvantage in pellet systems consists of the deterioration of food quality due to temperature loss as a result of service delays (Peffers, 1963).

Comparison of Transport Equipment

The quality and temperature-holding capabilities of transport equipment have not been studied intensely. Disposable and permanent serviceware, heated/chilled carts, and a pellet system have been compared by some researchers.

Heinemeyer (1972) and Mueller (1969) have compared disposable and permanent serviceware. One study found that disposables were well accepted by patients and that patients frequently stated food quality was improved by the use of disposables (Mueller, 1969). A spot test found that coffee in china cups had an initial temperature loss of 20° to 25°F., while plastic-coated paper cups cause almost no initial loss and coffee in these type of cups was 17° to 20°F hotter than that in china after ten minutes (Mueller, 1969). Heinemeyer (1972) found that most food served on disposables loss less heat than did similar foods served on permanent serviceware. Although disposables maintained hot foods at slightly higher temperatures, the permanent serviceware also maintained hot food at acceptable eating temperatures (Heinemeyer, 1972). It was concluded that it would seem unlikely that patients would appreciate or notice the 3° to 6°F difference in food temperatures (Heinemeyer, 1972).

Gee and Axelrod (1962) compared a pellet system with a heated/chilled cart. The two systems were studied considering time factors, thermal efficiency, capital investment, operating cost, and personnel and space requirements. In this study a time-lapse, from point of assembly to service, of 34 minutes occurred in the heated/chilled cart as compared to 21 minutes in the pellet system (Gee and Axelrod, May, 1962). This decrease in time-lapse due to decreased assembly and service time was shown to be critical, as it affected service temperature. Both systems yielded an initial temperature drop, with the pellet showing slightly better heat retention. After 30 minutes both systems showed similar temperatures, and after one hour the average food temperature was 98°F. in the pellet and room temperature in the heated cart. Therefore, due to decreased assembly and service time, the pellet system was concluded to have a temperature holding advantage. Cold foods were not considered in this study and lead to the recommendation for further research in this area. The pellet system eliminated four full-time and two part-time positions for the hospital due to decreased service time requirements. Capital expenses consisted of 27 heated/chilled carts at $42,500, compared to $15,857 for the pellet system and support equipment. The two systems both were found favorable in regard to patient satisfaction; however, an inconclusive test found a slightly higher degree of dissatisfaction with the heated/chilled cart system. In review of the research results, the hospital in this study selected the pellet system for service to all units except pediatrics and psychiatry, where the pellet heated to 450°F. was considered a possible hazard. The key factor for their selection of the pellet system in all other units was the decreased time from assembly to patient service which promoted an average service temperature of 153°F. in the pellet as compared to 140°F. in the heated/chilled cart.

Hypotheses

The null hypotheses of this study are stated as follows:

1. There is no significant difference in temperature changes in hot foods transported on trays in heated carts versus two pellet systems.

2. There is no significant difference in temperature changes in cold foods transported on trays in heated carts versus two pellet systems.

3. There is no significant difference in hot food quality in trays transported in heated carts versus two pellet systems, as measured by a panel of experts.

4. There is no significant difference in cold food quality on trays transported in heated carts versus two pellet systems, as measured by a panel of experts.

Definitions

Heated cart: For the purpose of this study a heated cart was a mobile unit divided into a hot and cold compartment used to transport trays from assembly to patient. In this case the system consists of plate warmer, china, silverware, styrofoam cups and single tray cart.

Pellet system: For the purpose of this study two pellet systems were defined. The metal cover pellet system consisted of a pellet oven, metal bases and covers, plates, plate warmers, and insulated cups and bowls. The plastic cover pellet system consisted of a pellet oven, metal bases, plastic covers, plates, plate warmers, styrofoam cups, and china bowls.

Panel of experts: The panel of experts consisted of two registered dietitians and a dietetic intern who had been instructed in evaluating food before and after transport.

Methods

This study involved a simulation of the tray service of the Veterans Administration Medical Center, Houston, Texas. The heated cart and the two pellet systems were studied through measurement of temperature and quality changes resulting after simulated transport. The study was conducted for fourteen consecutive week day breakfast and noon meal periods. Both hot and cold food items were evaluated. Breakfast food temperatures were representative of the last hospital ward served by the dietetic tray service. Noon food temperatures were representative of the first hospital ward served by the regular tray service. This variance in the sequence of the trays selected for study was done for pragmatic reasons and was not a function of the research design.

Procedure

Two sample trays were prepared and time-lapse of transport were simulated. Time as a variable was manipulated to represent the average service to a thirty-bed hospital ward. A standard for the time needed to serve a thirty-bed hospital ward was determined by averaging three actual observed times of service. This time was found to be 20 minutes. This standard time was used to simulate the length of time in tray assembly and delivery to the patient. The heated cart, metal cover pellet, and plastic cover pellet were used in simulated service with both hot and cold food items being studied. Two sample trays were prepared for each transport system. Sample tray #1 was used for determining post-transport temperatures; sample tray #2 was used to evaluate quality change. The study procedure steps, as outlined in Figure 1, were repeated for each type of transport. Step 1 was accomplished by pre-conditioning the transport equipment according to manufacturers' recommendations. These included heating and chilling carts for 45 minutes, pellets in pellet ovens for 90 minutes, and warming plates needed for service. For measuring the food temperatures (steps 2,7) a pyrometer was used. Step 5 was the simulated time for tray assembly. Step 6 was the simulated time for tray delivery. Step 7 involved removal of the tray from transport cart and simulation of patient bedside service.

The panel referred to in steps 4 and 7 consisted of two registered dietitians and a dietetic intern. Panel selection was based on member availability for both service times each study day and member interest in the study. A training session was held prior to initiation of the study to promote inter-rater reliability.

Criteria used by the panel to subjectively evaluate food quality and temperature change are shown in the score sheet (see Appendix A). The panel annotated subjective comments for these criteria at each the pre-transport and post-transport phases, as outlined in steps 4 and 7. Each panel member compared his respective pre- and post-transport comments and estimated the change observed utilizing the numerical code for scoring (range 0-6).

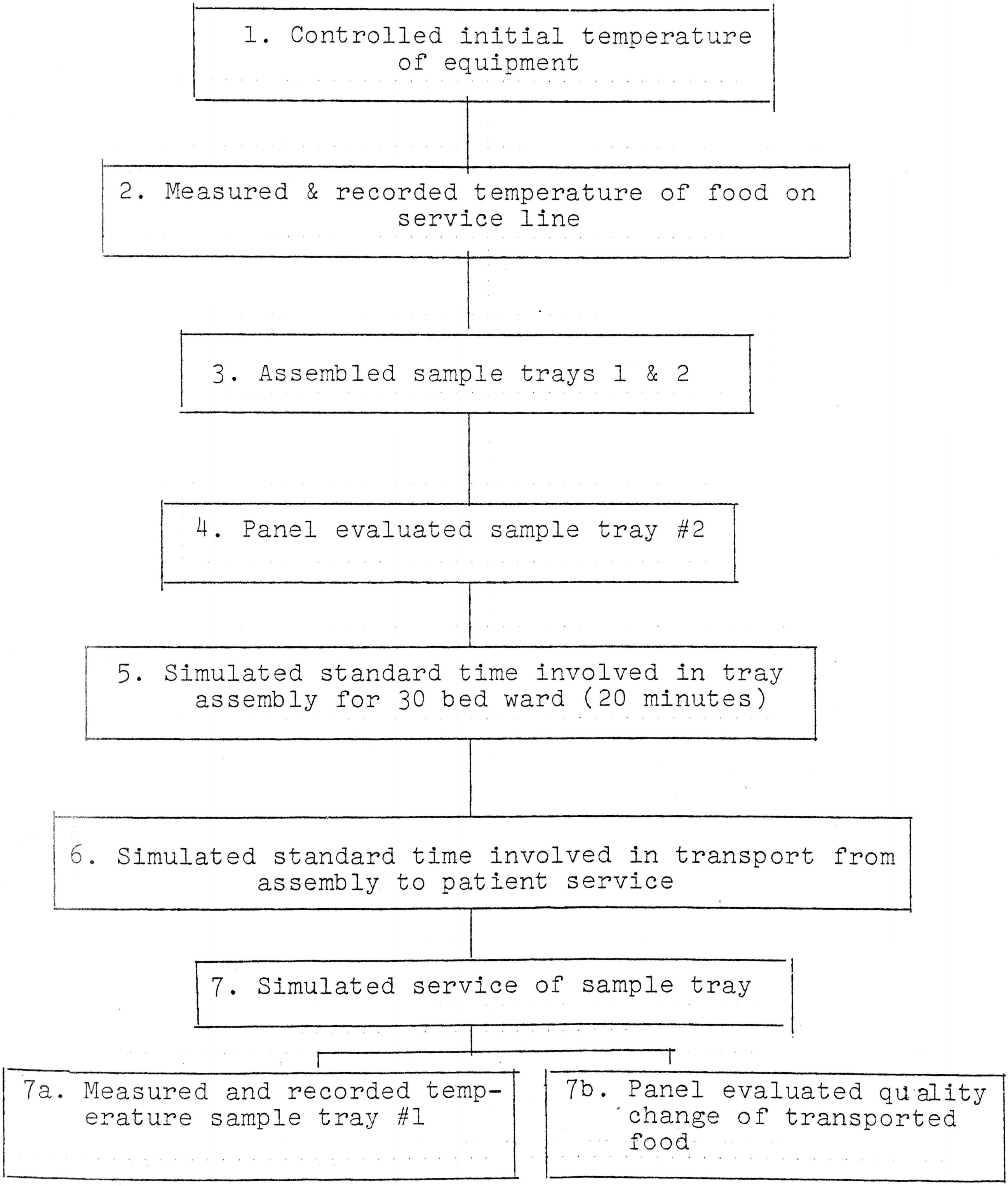

Figure 1. Diagram of the study procedure

Statistical Analysis

The independent variables in this study were the three types of transport equipment-- heated cart, metal cover pellet, and plastic cover pellet. The dependent variables were temperature and quality changes. A two-factor mixed design analysis of variance was used to determine significance of objective measures of temperature changes in hot and cold food items, $p < .05$ (Bruning, James, and Kintz, 1977; Huck, Cormier, and Bounds, 1974). The following are underlying assumptions of analysis of variance: (1) treatment groups are randomly selected from defined population; (2) treatment groups are independent of one another; (3) population data distributions are normal; (4) treatment groups are of equal size for homogeneity of variance; and (5) the effects of various factors on total variation are additive (Bruning et.al., 1977; Huch et.al., 1974).

Limitations

The research design for the study encompassed the following limitations:

(1) The mean holding temperature of the hot food prior to the assembly of sample trays was below the ranges of recommended holding temperatures for these foods.

(2) The two pellet systems studied were not actually in use at the hospital foodservice; this resulted in an inability to determine actual time-lapse from tray assembly to patient service for these types of transport equipment.

Results and Discussion

The food temperature and quality holding characteristics were measured in each of the three types of tray transport equipment for fourteen breakfast and dinner meal periods. Two breakfast periods were eliminated from the study due to equipment failure, leaving twelve breakfast meal periods for consideration. The panel of experts were instructed on the use of the scoring instrument for evaluating food quality changes and practiced scoring sample trays as a group prior to the study. The panel, as a group, discussed scoring techniques and established standards and criteria for using the scoring instrument.

Temperature differences between trials, i.e., between pre- and post-transport times, were found to be significant ($p < .01$) for all food items (see table 1). Between groups, i.e., between the types of equipment, no significant differences were found among hot or cold food items (see table 1). There were no significant differences found for hot or cold food items between groups by trials. Figures

Table 1

F-ratio and P values for Group, Trials, and Groups by Trials for Each Food Item

Food Item	GROUP		TRIALS		GROUP BY TRIALS	
	F-ratio	P	F-ratio	P	F-ratio	P
Breakfast						
Juice[a]	.455	.6441	81.638	.0001*	1.186	.3184
Hot Cereal[a]	1.672	.2020	175.814	.0001*	2.505	.0954
Entree[a]	.845	.5582	97.519	.0001*	.891	.5772
Coffee[a]	2.709	.0565	517.247	.0001*	1.380	.2615
Milk[a]	.655	.5304	329.217	.0001*	2.399	.1047
Toast[b]	1.487	.2518	12.783	.0024*	2.169	.1418
Dinner						
Entree[c]	.816	.5469	89.220	.0001*	1.080	.3503
Starch[a]	.296	.7496	85.477	.0001*	.917	.5878
Vegetable[d]	.179	.8378	244.042	.0001*	.377	.6941
Dessert[d]	.020	.9811	38.030	.0001*	.439	.6538
Iced Tea[c]	.647	.5338	46.808	.0001*	1.928	.1572
Milk[c]	.044	.9571	304.594	.0001*	.559	.5812

[a] $n = 12$

[b] $n = 7$

[c] $n = 14$

[d] $n = 13$

* $p < .05$

2 and 3 graphically show the lack of significant interaction for two food items, breakfast entree and dinner entree (see figures 2 and 3). The mean temperatures for all food items are summarized by meal period (see tables 2 and 3). The most desirable mean post-transport temperatures were recorded for the metal pellet system with the exception of breakfast coffee, breakfast milk, dinner dessert, and dinner iced tea (see tables 2 and 3).

Quality change scores recorded for hot and cold food items by the panel of experts do not appear significant (see Appendix B). This can be attributed to the lack of sensitivity in the scoring instrument. The evaluation instrument would be improved by using larger numerical change scores. The 0-6 score range was too limited to adequately evaluate between quality changes.

The results of this study indicate that for this hospital foodservice, none of the three types of transport equipment are effective in preventing a significant change in temperature of food items by trials or over time. Although reduced temperatures were expected, the most desirable transport equipment would lessen the significance in pre- and post-transport changes. This fact may account for the numerous types of transport systems marketed for hospital foodservice systems. None of the three transport

Table 2

Mean Pre-transport, Post-transport, and Group Temperatures of Breakfast Items by Transport Systems

Food Item	Heated Cart			Plastic Pellet			Metal Pellet		
	Pre	Post	Group	Pre	Post	Group	Pre	Post	Group
Juice[a]	49.42	55.25	52.33	52.67	56.75	54.71	47.17	53.33[c]	50.25[c]
Hot Cereal[a]	132.17	93.92	113.04	132.17	88.50	108.67	132.17	105.78[c]	116.75[c]
Entree[a]	123.67	86.67	105.17	123.67	93.75	108.71	123.67	97.08[c]	110.21[c]
Coffee[a]	145.58	130.17[c]	137.87[c]	137.50	119.83	128.67	140.67	124.50	132.58
Milk[a]	42.75	50.75	46.75[c]	44.17	50.42[c]	47.29	45.17	51.42	48.29
Toast[b]	100.43	82.57	91.50	100.43	94.00	97.21	100.43	95.82[c]	97.86[c]

[a] n = 12

[b] n = 7

[c] indicates mean temperature nearest desirable service temperature

Table 3

Mean Pre-transport, Post-transport, and Group Temperatures of Dinner Items by Transport System

Food Item	Heated Cart			Plastic Pellet			Metal Pellet		
	Pre	Post	Group	Pre	Post	Group	Pre	Post	Group
Entree[a]	124.00	90.00	107.00	124.00	97.64	110.82	124.00	100.29[d]	112.14[d]
Starch[b]	127.33	89.17	108.25	127.33	97.92	112.62	127.33	98.83[d]	113.58[d]
Vegetables[c]	140.62	90.62	115.61	140.62	95.69	118.31	140.62	96.15[d]	118.38[d]
Dessert[c]	48.92	52.46[d]	50.69[d]	50.15	54.08	52.11	51.00	53.69	52.34
Iced Tea[a]	26.07	32.36	29.21[d]	28.86	32.29[d]	30.57	28.71	32.43	30.57
Milk[a]	46.07	51.00	48.53	46.50	50.93	48.71	56.29	50.57[d]	48.43[d]

[a] $n = 14$

[b] $n = 12$

[c] $n = 13$

[d] indicates mean temperature nearest desirable service temperature

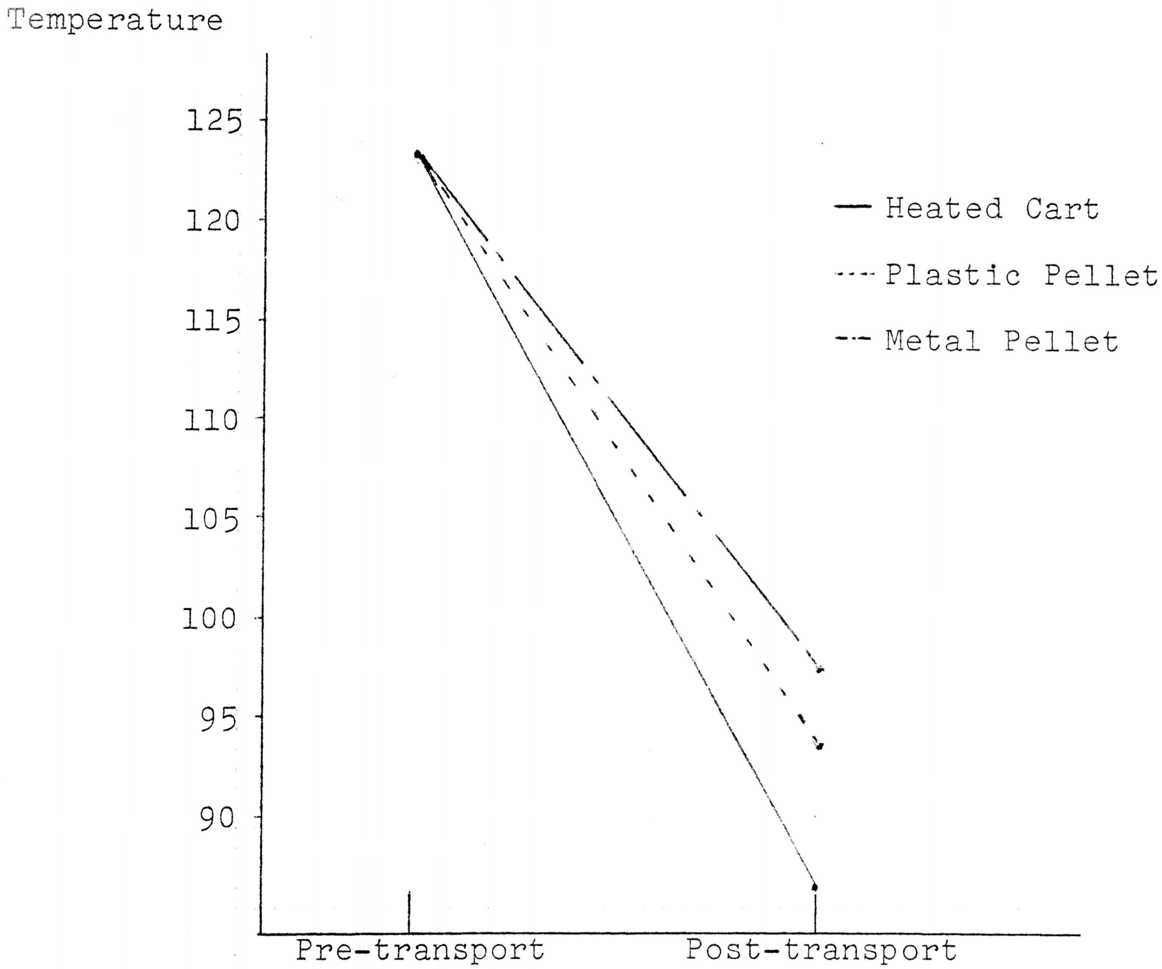

Figure 2. Mean temperatures for breakfast entree, pre- and post-transport by equipment

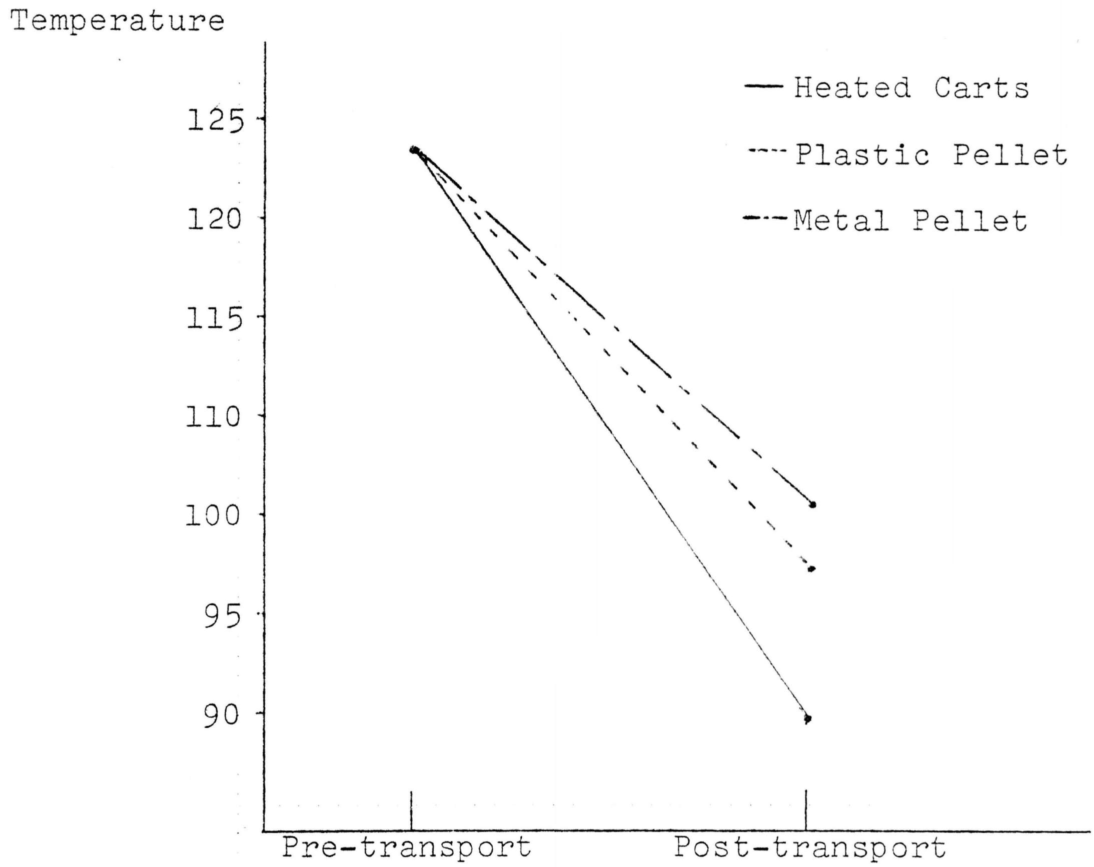

Figure 3. Mean temperatures for dinner entree pre- and post-transport by equipment

systems studied have optimal temperature holding capabilities over the simulated 20 minute service time. Peffers (1963) defined optimal time from assembly to service as nine minutes in pellet systems and undefined in heated carts when connected to electric supply. Although this study cannot support Peffers time recommendations, it does indicate that food transport times should be minimal to reduce signifcant changes in food temperatures regardless of the three types of transport equipment studied.

In this foodservice system, there were no significant differences noted between groups. The F-ratio statistic between groups answers the question: is there a significant main effect of the between groups factor (Huck et.al., 1974). In this study, this would be interpreted as: is there significant difference between the temperature holding performance of the three types of transport equipment <u>per se</u>? If there were such a significance, it would mean that the types of equipment differentially affect the temperature holding performance, when the food temperatures are averaged across the two testing periods. Bruning and Kintz (1977) refer to this aspect as a "comparison of the overall performance of the experimental groups (p. 21)." Within this hospital foodservice; therefore, there is no significant difference in the "overall performance" of the three types of transport equipment. There was a trend for more desirable mean group temperatures for the metal cover pellet transport equipment, with the exceptions of breakfast coffee, breakfast milk, dinner dessert, and dinner iced tea (see tables 2 and 3). This trend may indicate a slight advantage for the metal cover pellet transport within the study foodservice system.

There were no significant differences for groups by trials within this foodservice system. The F-ratio statistic for groups by trials answers the question as to whether the trend of performance across the two testing periods are similar for all study groups (Huck et.al., 1974). Bruning and Kintz (1977) describe this as the evaluation "in relation to the passage of time between measuring periods" (p. 21). In terms of this study, this would be interpreted as: is there a significant difference between the three types of transport equipment in terms of trend of performance over pre-determined periods of passage of time? This statistic thus represents an estimator of the performance of three specified types of equipment within two specified time periods. Though no significant differences were found for equipment type over time passage, the mean post-transport temperatures are slightly more desirable for foods served in a metal cover pellet system with the exception of breakfast coffee and dinner desserts served in a heated cart and breakfast milk and dinner iced tea served in a plastic cover pellet system (see tables 2 and 3). In the hospital foodservice of this study, the overall results indicate that a metal cover pellet system is slightly more efficient in holding food temperatures when compared to a plastic cover pellet system or heated cart. Gee and Axelrod (May 1962; June 1962) also found a pellet system to be superior to a heated cart in holding food temperatures.

It is interesting to note that the two pieces of insulated plastic support equipment, beverage cups and cereal bowls, used with the metal pellet system were not significant in improving post-transport temperatures. The plastic cereal bowl held hot cereal at a mean of 11.86°F. higher than china cereal bowls. This temperature may be discernable by the consumer, justifying expenditure of funds and use of this equipment. The plastic beverage cups held coffee at a mean of 5.67°F. lower than disposable styrofoam beverage cups. The high incidence of pilferage and cost of replacement of the plastic beverage cup may indicate advantages in the use of disposable styrofoam cups. The temperature holding advantage of disposable cups delineated in this foodservice system also was found by Mueller (1969). There were no significant differences in cold food items among the different types of transport equipment, as evaluated by pre- and post-transport temperatures.

In this foodservice system, the initial temperature of food items prior to tray assembly was a major uncontrollable variable of this study. The mean holding temperatures for hot food items were consistently at or below the preferred serving temperatures of 140 - 170°F. (Thompson and Johnson, 1963; Ross, 1971; Blaker et.al., 1961). As the initial temperatures of hot food items were within acceptable serving temperatures, there was no allowance for the normal cooling rate of food items. Evaluation of the equipment holding qualities were compounded by this cooling rate of food items. The cooling rate curve proposed by Blaker et.al. (1961) indicates that the cooling rate slows as temperatures between environment and food item begin to equalize. Due to the low initial food temperatures it can be assumed that the cooling rate was decreased, influencing the temperature results of this study. It also became apparent that the cooling rate of food items varied considerably with type of food product. The use of varied menu items in this study thus complicated the interpretation of results.

For the purpose of this study the time-lapse between tray assembly and simulated service was held constant at 20 minutes for each of the three types of transport equipment. Gee and Axelrod (May 1962; June 1962) found that the major advantage of the pellet system of tray transport was a reduction in the time-lapse between assembly and service. In this foodservice system due to the regular use of a heated cart transport and unfamiliarity with the two pellet systems, a reduction in assembly to service time was not observable; therefore, the 20 minute constant may not be representative of pellet systems. A reduction in time between assembly and service may have led to significance between pre- and post-transport temperatures in the pellet type systems versus heated carts.

Conclusions

Within the foodservice system of this study, there were no significant differences in overall equipment performance between groups, i.e., equipment type, and between groups by trials, i.e., time passage. Thus the null hypotheses in this study failed to be rejected. These two hypotheses were: there is no significant differences in temperature changes in hot or cold foods transported on trays in heated carts versus two pellet systems. The metal cover pellet was found to have slightly better mean group and post-transport temperatures for most food items, as compared to the two other transport systems.

The initial food temperatures in the foodservice system in this study were below acceptable standards. This resulted in the mean post-transport temperatures for all hot food items being below preferred service temperatures, regardless of type of transport equipment. In this foodservice system, the holding capabilities of the transport equipment were not challenged due to low pre-transport temperatures of the food.

The results of this study are unique to the operations of a specific foodservice system. A study of this nature conducted under laboratory conditions could be valuable. In that instance, the variables of initial food temperature, type of food item, and cooling rate of food would be more controllable. Such a study would isolate information about the holding capabilities of tray transport equipment, eliminating other variables. However, the value of testing and studying tray transport equipment in an actual foodservice system should not be underestimated. Foodservice systems do not comply with laboratory control; there is variability in initial food temperature, cooling rates of food, personnel, time-lapse, and menu items. Only by observing and recording equipment performance under actual conditions of use can the most effective tray transport equipment be selected for any specific foodservice system. Therefore, it seems advisable that tray transport equipment be tested in the actual foodservice system prior to selection of equipment for patient service.

Implications for Further Research

Results of this study indicated that the metal cover pellet has a slight advantage in temperature holding abilities for the foodservice system studied, as compared to plastic cover pellet or heated cart. This study further indicated that of the three types of transport equipment investigated, none of the systems held food temperature at an acceptable or optimal service condition. Other types of tray transport equipment should be studied to determine temperature and quality holding characteristics.

Variability in cooling rate of food items has been observed. Both the pre-service holding temperature of food items and the cooling rate are critical factors. Further study is needed to determine optimal pre-service temperatures of food items in various types of equipment. Time-lapse from tray assembly to patient service has been noted as a major variable in food quality and temperature changes. Therefore, the food cooling rate over time should receive further study. Combinations of existing transport equipment, i.e., heated cart with pellet system, and development of new transport equipment should be explored.

In the foodservice system studied, the temperatures were below acceptable standards. The effect of development and implementation of an educational program for cooks with the objective of correcting this problem, may be valuable.

The holding capabilities of tray transport equipment studied under optimal laboratory conditions would provide a method of comparing the many transport systems available to a foodservice system.

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Appendix A

QUALITY AND TEMPERATURE CHANGE SCORE SHEET

Circle type of equipment, meal, and category of food items:

Date ________________

Heated Cart
Plastic Cover Pellet
Metal Cover Pellet

Breakfast/Lunch

Cold/Hot food items

0 No change between pre- and post-transport testing.

2 Slight degradation between pre- and post-transport testing.

4 Moderate degradation from pre- and post-transport testing.

6 Severe degradation from pre- and post-transport testing.

	Pre-transport	Post-transport	Change Score
Appearance of food and tray			
Color			
Attractiveness			
Neatness			
Texture			
Toughness			
Tenderness			
Creamyness			
Dryness			
Moistness			
Temperature			
Very hot			
Hot			
Warm			
Room temperature			
Cool			
Cold			

Appendix B

Meal Breakfast Quality Evaluated Appearance Cold Food Item

Equipment Type Panel Member	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heated Cart														
MP	b	0	0	a	0	b	0	0	0	0	0	0	0	a
SM	b	0	0	0	0	b	0	0	0	0	a	a	0	1
PB	b	0	0	0	0	b	0	0	0	0	0	0	0	0
Plastic Pellet														
MP	b	0	0	a	0	b	0	0	0	0	0	0	0	a
SM	b	0	0	0	0	b	0	0	0	0	a	a	0	1
PB	b	0	0	0	0	b	0	0	0	0	0	0	0	0
Metal Pellet														
MP	b	0	0	a	0	b	0	0	0	0	0	0	0	a
SM	b	0	0	0	0	b	0	0	0	0	a	a	0	0
PB	b	0	0	0	0	b	0	0	0	0	0	0	0	0

[a] Indicates absence of panel member for that evaluation

[b] Meal not evaluated due to equipment failure

Meal Breakfast   Quality Evaluated Texture   Cold Food Item

Equipment Type Panel Member	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heated Cart														
MP	b	0	0	a	0	b	0	0	0	2	0	0	0	a
SM	b	0	1	a	0	b	1	0	0	2	a	a	0	0
PB	b	1	0.5	1	1	b	1	1	1	4	0.5	0	0.5	0.5
Plastic Pellet														
MP	b	2	0	a	0	b	0	0	0	2	2	0	0	a
SM	b	0	0	0	0	b	0	0	0	0.5	a	a	0	0.5
PB	b	0	0.5	0.5	1	b	0	0.5	0	1	0.5	0.5	0.5	0.5
Metal Pellet														
MP	b	0	0	a	0	b	0	0	1	2	0	0	0	a
SM	b	0	0	0	0	b	1	0	0	0	a	a	0	0
PB	b	0	0.5	1	0	b	0	0	0	1	0.5	0.5	0.5	0

[a] Indicates absence of panel member for that evaluation

[b] Meal not evaluated due to equipment failure

Meal Breakfast Quality Evaluated Temperature Cold Food Item

Equipment Type Panel Member	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heated Cart														
MP	b	2	6	a	2	b	2	4	2	2	0	4	0	a
SM	b	4	2	0	2	b	1	2	1	1	a	a	0	1
PB	b	1	1	1	2	b	0	0.5	0.5	4	0	0	0	0
Plastic Pellet														
MP	b	4	2	a	4	b	0	2	2	0	2	0	0	a
SM	b	0	4	0	0	b	1	2	0	0	a	a	0	1
PB	b	0	0.5	1	1	b	0	0.5	0	1	1	0	0	0
Metal Pellet														
MP	b	4	6	a	4	b	2	2	2	2	2	0	0	a
SM	b	4	0	0	0	b	1	2	0	0	a	a	0	0.5
PB	b	0	1	0	2	b	0	0	0	1	1.5	0	0	0.5

[a] Indicates absence of panel member for that evaluation

[b] Meal not evaluated due to equipment failure

Meal Breakfast Quality Evaluated Appearance Hot Food Item

Equipment Type Panel Member	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heated Cart														
MP	b	0	0	a	0	b	0	0	0	0	0	0	0	a
SM	b	2	0	0	0	b	0	0	1	1	a	a	0	1
PB	b	1	2	0	0	b	0	0	1	2	0	1	1	0.5
Plastic Pellet														
MP	b	0	0	a	0	b	0	0	0	0	0	0	0	a
SM	b	0	0	0	0	b	1	0	1	1	a	a	1	0
PB	b	0.5	0	0	1	b	0	0	0	0	0	0	0	0
Metal Pellet														
MP	b	0	0	a	0	b	0	0	0	0	0	0	0	a
SM	b	1	0	0	0	b	0	2	0	1	a	a	0	0
PB	b	1	0.5	0	0	b	0	0	0	0	0	0	0.5	0

[a] Indicates absence of panel member for that evaluation

[b] Meal not evaluated due to equipment failure

Meal Breakfast Quality Evaluated Texture Hot Food Item

Equipment Type Panel Member	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heated Cart														
MP	b	0	1	a	2	b	0	0	0	0	0	0	0	a
SM	b	2	0	0	1	b	2	2	0	0	a	a	0	0.5
PB	b	1	1	0	1	b	1	1	1	1	1	1	0.5	0
Plastic Pellet														
MP	b	0	0	a	0	b	0	0	0	0	0	0	0	a
SM	b	1	0	0	2	b	0	2	0	0	a	a	0	0
PB	b	0.5	+0.5	1	2	b	1	0.5	1	0	0.5	0.5	0.5	0
Metal Pellet														
MP	b	0	0	a	0	b	0	0	0	0	2	0	0	a
SM	b	0	0	1	1	b	0	2	0	0	a	a	1	0
PB	b	+0.5	1	0.5	1	b	0.5	1	0	0	0	0.5	0	0

[a] Indicates absence of panel member for that evaluation

[b] Meal not evaluated due to equipment failure

Meal Breakfast Quality Evaluated Temperature Hot Food Item

Equipment Type / Panel Member	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heated Cart														
MP	b	4	1	a	2	b	4	4	2	4	2	0	4	a
SM	b	2	4	4	4	b	6	4	2	4	a	a	1	4
PB	b	2	2	1	2	b	2	2	2	2	2	2	1	1
Plastic Pellet														
MP	b	4	4	a	6	b	2	6	2	4	4	0	4	a
SM	b	0	2	6	2	b	6	4	2	2	a	a	2	1
PB	b	2	2	3	3	b	2	2	1	2	1.5	2	2	0.5
Metal Pellet														
MP	b	2	6	a	4	b	6	6	6	4	4	2	2	a
SM	b	2	2	2	2	b	4	6	2	4	a	a	0.5	1
PB	b	2	2	1	3	b	2	2	2	1	1.5	2	2	0

[a] Indicates absence of panel member for that evaluation
[b] Meal not evaluated due to equipment failure

Meal Dinner Quality Evaluated Appearance Cold Food Item

Equipment Type Panel Member	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heated Cart														
MP	0	0	0	a	0	0	0	0	0	0	0	0	0	a
SM	0	0	0	0	0	0	0	0	0	0	0	0	a	0
PB	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plastic Pellet														
MP	0	0	0	a	0	0	0	0	0	0	0	0	0	a
SM	0	0	a	0	0	0	0	0	1	0	0	0	a	0
PB	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metal Pellet														
MP	0	0	0	a	0	0	0	0	0	0	0	0	0	a
SM	0	0	a	0	0	0	0	0	0	0	0	0	a	0
PB	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] Indicates absence of panel member for that evaluation

Meal Dinner Quality Evaluated Texture Cold Food Item

Equipment Type Panel Member	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heated Cart														
MP	0	0	0	a	0	0	2	0	1	0	2	2	1	a
SM	0	0	a	0	0	0	0	0	2	0	1	2	a	1
PB	1	1	1	0	0.5	0	1	1	1	0.5	0.5	1	0.5	0.5
Plastic Pellet														
MP	0	0	0	a	0	4	1	0	2	0	2	1	0	a
SM	0	0	a	0	0	0	0	0	2	0	1	1	a	0
PB	0	1	1	1	1	1	0	0	1	0.5	0.5	1	0	0
Metal Pellet														
MP	0	0	0	a	0	4	0	0	1	0	0	2	0	a
SM	0	0	a	0	0	0	1	0	1	0	0	1	a	0.5
PB	1	2	1	1	0	0	1	1	2	1	0.5	0	0.5	0.5

[a] Indicates absence of panel member for that evaluation

Meal Dinner   Quality Evaluated Temperature   Cold Food Item

Equipment Type Panel Member	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heated Cart														
MP	0	4	4	a	2	2	0	2	0	2	2	0	0	a
SM	4	2	a	0	0	0	2	4	2	0	2	2	a	1
PB	1	0.5	1	1	3	2	2	1	1	0.5	1	0.5	0.5	0.5
Plastic Pellet														
MP	0	6	2	a	4	2	0	0	2	2	0	0	0	a
SM	0	0	a	0	1	0	2	0	0	1	2	0	a	1
PB	1	1	1	0	2	1	1	1	0.5	0.5	1	0.5	0.5	0
Metal Pellet														
MP	0	4	1	a	0	2	2	4	2	4	0	1	2	a
SM	4	2	a	2	2	0	2	4	2	0	1	0	a	0.5
PB	1	1	2	2	1	0.5	1	1	1	1	1	0.5	0.5	0

[a] Indicates absence of panel member for that evaluation

Meal Dinner   Quality Evaluated Appearance   Hot Food Item

Equipment Type / Panel Member	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heated Cart														
MP	0	0	0	a	0	0	0	0	0	0	0	0	0	a
SM	0	0	a	0	1	0	1	1	1	0	1	2	a	0
PB	1	0	0	1	1	0	0	0	0	0	0	0.5	0	0
Plastic Pellet														
MP	0	0	0	a	0	0	0	0	0	0	0	0	0	a
SM	0	0	a	0	1	0	0	0	0	1	0	2	a	0
PB	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metal Pellet														
MP	0	0	0	a	0	0	0	0	0	0	0	0	0	a
SM	1	2	a	0	1	0	1	0	0	1	1	0	a	0
PB	0	1	0	0.5	0	0	0	0	0	0	0	0	0	0

[a] Indicates absence of panel member for that evaluation

Meal Dinner   Quality Evaluated Texture   Hot Food Item

Equipment Type Panel Member	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heated Cart														
MP	0	0	0	a	0	0	0	0	0	0	0	1	2	a
SM	2	2	a	0	2	0	0	0	1	0	0	0	a	2
PB	0	1	0	2	1	1	0	0	3	2	1	1	0	1
Plastic Pellet														
MP	0	0	0	a	0	0	0	0	0	0	0	1	0	a
SM	0	0	a	0	1	0	0	0	1	0	0	0	a	2
PB	0	0	0	0	0	0	0	0	0	0.5	0	0	0	1
Metal Pellet														
MP	0	0	a	0	0	0	0	0	0	0	0	0	0	a
SM	2	0	a	0	2	2	1	0	0	0	0	0	a	0
PB	0	1	0	0	0.5	2	0	0	0	0	0	0	0	0

[a] Indicates absence of panel member for that evaluation

Meal Dinner   Quality Evaluated Temperature   Hot Food Item

Equipment Type Panel Member	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heated Cart														
MP	0	1	2	a	2	0	2	6	4	4	0	2	2	a
SM	4	4	a	4	2	4	4	6	4	4	2	4	a	2
PB	2	2	2	3	3	1	1	2	1	2	1	1	0	2
Plastic Pellet														
MP	2	2	2	a	2	2	2	6	2	6	2	2	2	a
SM	2	4	a	0	0	0	4	4	1	1	0	4	a	2
PB	2	0	1	0	0	1	2	2	0.5	2	0.5	2	0	2
Metal Pellet														
MP	1	2	0	a	2	0	2	4	0	4	0	0	2	a
SM	4	2	a	1	1	2	4	4	4	2	1	1	a	2
PB	2	0	1	2	1	1	1	2	1	1	1	1	0	0

[a] Indicates absence of panel member for that evaluation

TEXAS WOMAN'S UNIVERSITY
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HOUSTON, TEXAS 77030

AGENCY PERMISSION FOR CONDUCTING STUDY

The Veterans Administration Medical Center, Houston

grants to Sharon Morris Allenson
a student enrolled in the Department of Nutrition and Food Science at Texas Woman's University, the privilege of its facilities in order to study the following problem:

The use of three types of tray transport equipment in a hospital foodservice system.

The conditions mutually agreed upon are as follows: (to be completed by the Agency Representative)

1. The agency (may) (~~may not~~) be identified in the final report.
2. The names of consultative or administrative personnel in the agency (may) (~~may not~~) be identified in the final report.
3. The agency (wants) (~~does not want~~) a conference with the student when the report is completed.
4. The agency is (willing) (~~unwilling~~) to allow the completed report to be circulated through interlibrary loan.
5. Other ____________________

Date: March 23, 1979

Lois L. Good RD
Signature of Agency Representative

Sharon Morris Allenson
Signature of Student

Signature of Research Committee Chairman, TWU Faculty Member

Number of forms required: one completed original and three duplicated copies (with signatures).

Distribution: one copy each to student (original); Agency, Dean of Graduate School - (to accompany prospectus); Dept. of NGS, TWU-Houston Center.