AMRL MEMORANDUM M-32

AEROSPACE FEEDING CONSOLE EVALUATION

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March 1963

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FOREWORD

The evaluation of the feeding console was conducted under Project Nr 6373, "Equipment for Life Support in Aerospace", and Task Nr 637305, "Life Support Accommodations Integration and Analysis." Mr. G. W. Filson served as test director. The evaluation was a combined effort of the Accommodations Section, Sustenance Branch, Life Support Systems Laboratory, and the Biospecialties Section, Physiology Branch, Biomedical Laboratory, both of the 6570th Aerospace Medical Research Laboratories, W-PAFB, Ohio.

The console was designed and built under Contract AF 33(616)-7503 by Whirlpool Corporation, St Joseph, Michigan, with Mr. H. E. Brehm as principle investigator. Mr. C. A. Metzger served as contract monitor. Food items and correlated equipment were furnished by the Quartermaster Corps and Whirlpool Corporation respectively.

The authors wish to express their sincere appreciation to Miss B. Finkelstein, Mrs. R. Lawson, Dr. S. A. London, Lt P. A. Lachance of the Biospecialties Section and Mr. C. A. Metzger, Lt D. Fordham, MSgt L. West of the Accommodations Section for their assistance in the test. Appreciation is also extended to Mr. L. Henkel and Mr. D. Nichols of Whirlpool Corporation for their interest and assistance in the test. Dates of evaluation were April 24, 1962 through May 8, 1962.

ABSTRACT

A compact feeding console designed for storing, preparing, and dispensing food items in a space vehicle has been evaluated during a simulated 3-man, 14-day space flight. The engineering design of the console and accessories were evaluated and the acceptability and nutritional value of the food recommended for use in the console were measured. Further research must be conducted to improve the designs incorporated in the console. Design should be compatible with the diet and type of processed food to be furnished the crewmembers.

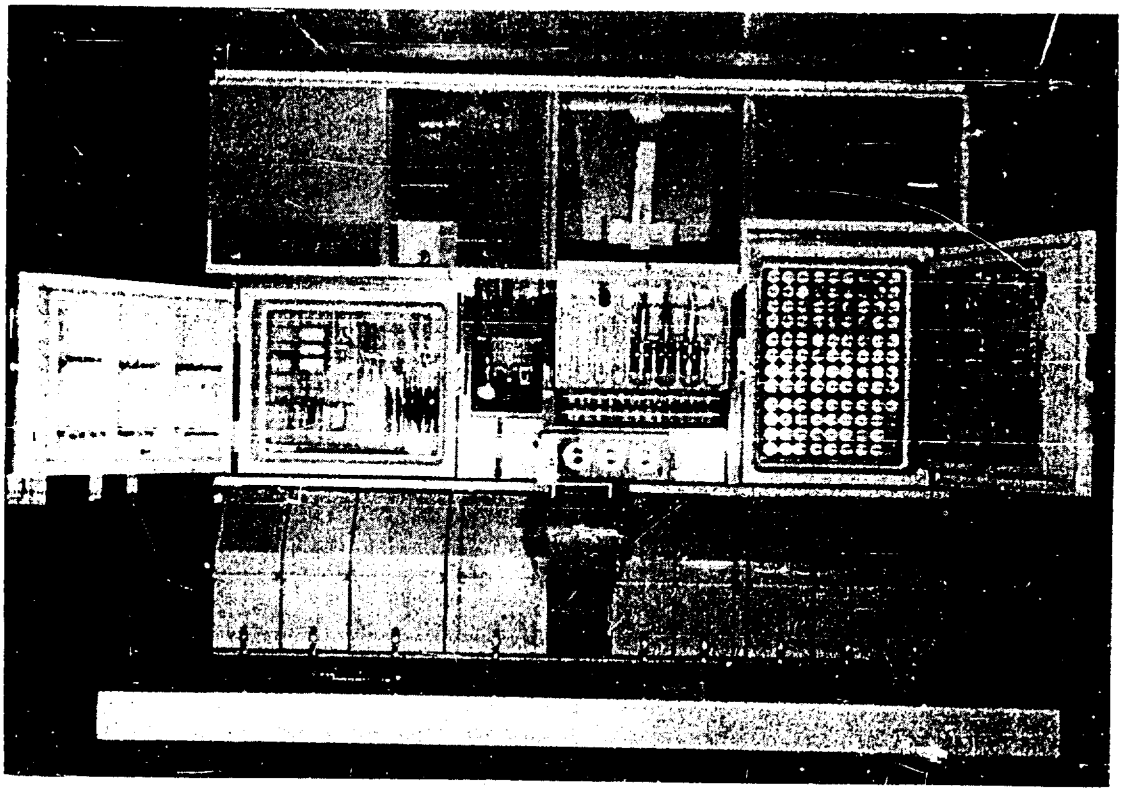
INTRODUCTION

Manned space missions will require nutritional support of the highest possible quality. Nutritionists and food technologists will carefully prepare food of specific caloric content that will have the highest possible acceptability to the crewmembers. Equally important are methods for storing, preparing, and dispensing the foods and disposing of food wastes. The compact feeding console evaluated in this test was designed to accomplish these necessary procedures inherent in the feeding process (fig.1).

The purpose of the test was to evaluate the engineering design of the console and accessories, and to evaluate acceptability and nutritional value of the food used in the test.

Several varieties of food were used during the evaluation. Some were contained in cans and needed to be either heated or cooled. Some were dehydrated and were stored in both cans and plastic tubes. These were reconstituted with either hot or cold water. Frozen foods in cans and plastic wrappers were also used. These were thawed before eaten.

The evaluation was conducted with the console in an open room. Test subjects were permitted to pursue their normal daily activities. The first portion of the report covers the engineering problems relevant to the console and information pertaining to the menu. A bacterial analysis of the water is included in appendix V.



AEROSPACE COMPACT FEEDING CONSOLE

Figure 1

PROCEDURE

The evaluation simulated a 3-man, 14-day, space flight. Subjects were restricted to food and drink contained within the console. Food and drink for the entire test run, except water which was added as needed, was stored in the console. Immediately before the test, the console was cleaned and stocked with the food items.

A portable 28-volt dc generator was used to supply power. The frozen foods were cooled to -20°F before being placed in the freezer. Since these foods were to be maintained at or near 0°F, the additional cooling reduced the initial load on the freezer. Thermocouples were installed in the freezer and cooler to permit temperature checks. Since the freezer was designed to hold more food than was programmed for the test, frozen orange juice was used to fill the empty spaces. Thermocouples were installed in the freezer and cooler and in the food cans being stored in them so that the temperature could be checked periodically. One thermocouple was attached to the hot water outlet in the feeding console to test the water temperature.

The 14-day menu for 3 men (appendix I) was recommended by Miss Beatrice Finkelstein. It was comprised of 264 precooked canned items, 54 precooked-dehydrated canned items, 27 frozen canned items, 171 frozen ready food items, 168 tubed instant beverages, 99 tubed dehydrated soups and cereals, and 42 packets of candy. Food containers were weighed before and after each meal to determine the amount of food consumed. A water consumption record was also kept on a per man basis. Drinking water was recorded separately from the water used to reconstitute dehydrated foods. Total water consumption was also recorded. Body weight was recorded each morning before breakfast. The subjects were instructed to follow the menu precisely with no interchange of food items permitted. Each subject recorded the quantity (weight) of each food item he consumed and rated each food item as to his like or dislike on a 9-point scale (appendix II). The subjects were cautioned not to discuss their rating of the items to avoid influencing each others true preference.

The test began with the noon meal on 24 April 1962 and was completed after breakfast on 8 May 1962. Meals were eaten during working hours, except on weekends when the subjects ate at their convenience. Subjects were allowed to take some drinking water and after meal snacks home with them. They were permitted to engage in normal work activities, but were restrained from strenuous activity such as athletics. Because of scheduling problems, the subjects were allowed to eat simultaneously, a situation for which the console was not designed. However, this change probably did not affect the evaluation of the console or food.

The engineering evaluation can best be described by discussing each phase of the feeding process and related components of the console. There are five phases: storage, preparation, dispensing, disposing, and clean-up.

STORAGE

Both cans and plastic tubes containing food were stored in the bins in the upper part of the console. Cans and bread items were stored in the freezer. Water was stored temporarily in the storage and hot water tanks.

Dry Storage:

The storage bins proved satisfactory (fig. 2); however, it was found that slight changes would be desirable. The narrow, deep, honeycomb-like cavities used to store the tubes proved hard to clean before and after the test. Also, once the empty used cans were fitted with plastic sealing caps (after iodophor injection for bacteria control) it was difficult to replace them in the cavities provided for their storage. The caps were too large to fit into the cavity designed to accommodate the can. As the cans were forced into the cavities, some of the plastic caps would loosen. Since there was evidence of pressure build-up in the cans, the caps should not be disturbed once they have been secured.

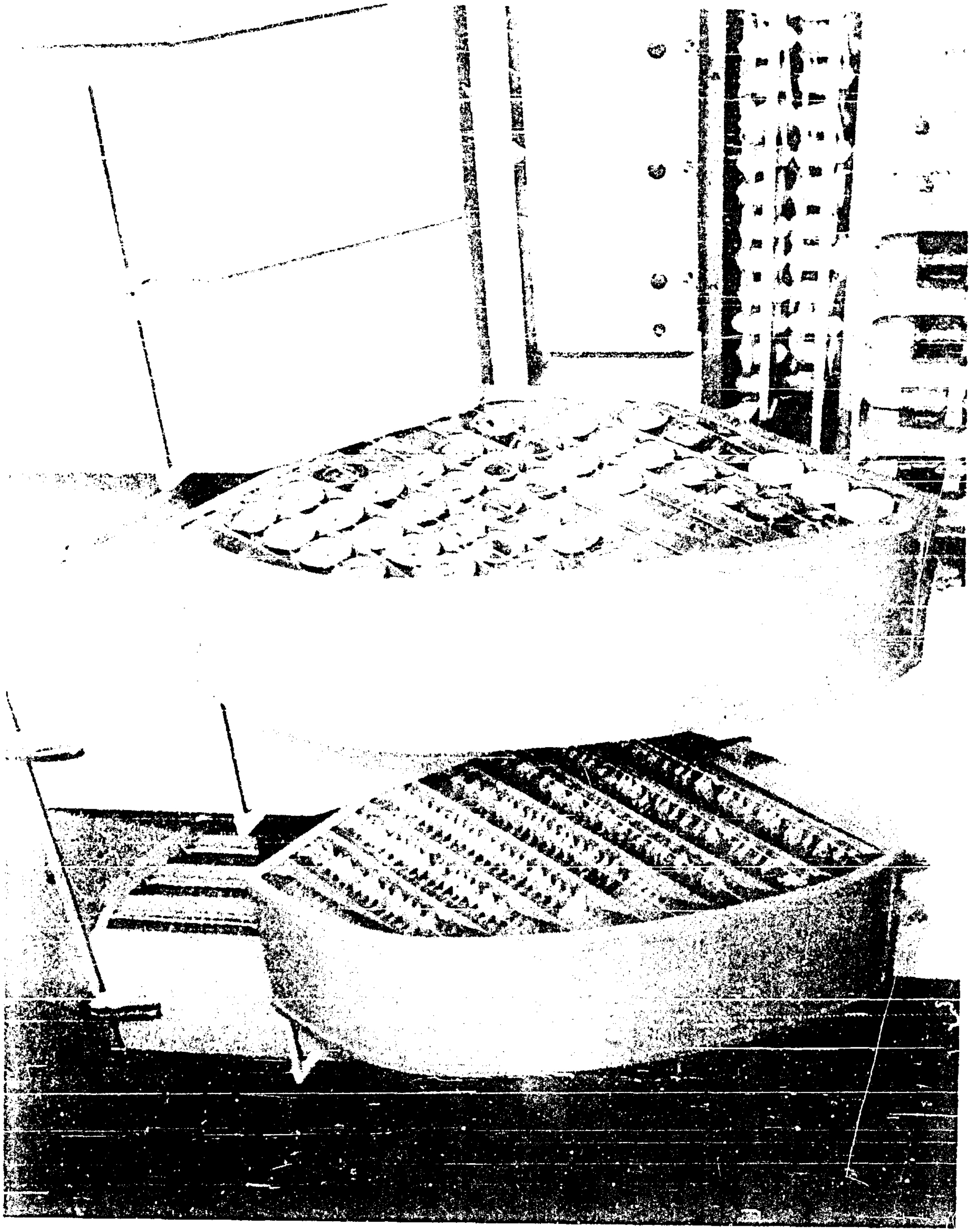
Frozen Storage:

The freezer was unable to keep the temperature sufficiently low. The freezer and refrigerator operate on the thermoelectric principle, using the cold side of thermoelectric modules as the cooling media. The freezer compartment was designed to hold the temperature of its contents at 0°F±5 at a cabin atmosphere temperature of 97°F maximum. When at one point the freezer was not functioning properly and the manufacturer was notified, they sent a thermoelectric engineer to check the resistance of the freezer modules. A high resistance in the modules would prevent sufficient current from passing through the freezer, thus retarding its cooling effect. Several modules were found to be of higher resistance than anticipated. One was found to be of very high resistance and was replaced. A subsequent test run of the freezer proved that replacing the faulty module allowed the freezer to reach a temperature of 4°F. No further work was done on the freezer.

Water Storage:

The water storage system performed satisfactorily, however, the water had an odd taste (information on the water is included in appendix V.) A simpler method of filling the tanks should be incorporated in future designs. Presently, a hand pump is used, but it is a slow, inefficient process. A method should also be devised to release the pressure on the bellofram during the filling process. This could be accomplished by compressing the springs that apply the pressure on the bellofram. Presently, pumping action must overcome this pressure to fill the tanks. When integration with other cabin components is available, a direct line from the water recycling system to the storage tank is recommended. A small electric, or hand powered pump could be used to create the flow. This would simplify the transfer process, and eliminate the possibility of water leakage into the cabin atmosphere.

It is necessary to unscrew a plug to bleed the air from the water system during the filling process. The plugs are hard to manipulate and are not convenient. A hand operated valve would be an improvement over the wrench-operated plug.



DRY STORAGE

Figure 2

Iodophor Storage:

The iodophor storage unit was satisfactory. However, a small portable unit, e.g., syringe, would be preferred to the large storage tank so the crewman would not have to leave his seat to insert the iodophor into the used tubes and cans. These small units could be stored in, or attached to the eating tray. A tablet or pill to replace the iodophor should be considered.

PREPARATION

Preparing the food during the test created no serious problems. The subjects alternated serving and preparing food that had to be precooked or preheated for the next meal. This was usually done immediately following each meal. Foods that could be prepared in a short time were fixed by each subject just before eating.

Dehydrated Foods:

In preparing dehydrated foods, water had to be added from either the hot or room-temperature water dispensors. No problems resulted when water was added to cans of dehydrated food, but there were problems with the tubes. After the tops were cut from the tubes, it was difficult to get the duckbill into the tube. Once in the tube, water would force its way back through the opening, especially if the food was concentrated in that end of the tube. A longer duckbill would alleviate this problem.

Water Dispensing Pump:

The sharp edges of the water dispensing pump irritated the user's hands when the pump was being drawn out and pushed in (fig. 3). A gun-type handle arrangement with a trigger valve would be more acceptable. Obviously there are other suitable solutions.

Precooked Foods:

Precooked canned foods were heated before they were eaten. The cans were placed in the console oven for between 20 and 30 minutes before eating (fig. 4). The oven functioned very well, bringing the temperature of the food to an optimum point, thus enabling the subjects to eat without waiting for cooling or reheating.

Heated cans had to be handled with the insulated glove when removed from the oven. The glove was worn until all cans were secured in their expellers. The glove was also worn while placing the feeding nipples on the cans.

Feeding Trays:

Immediately prior to each meal the food and expellers were secured to the feeding trays (fig. 5). When the three subjects ate simultaneously, two trays were set up on an adjoining table, and one was used in its proper place on the console. A single tray should be adequate for three crewmen, since they will eat at different times.

WATER DISPENSING PUMP
Figure 3

CONSOLE OVEN
Figure 4

If everything functions as it should, there will be little or no cleaning of the trays required. Since the trays are used for holding the food and food expellers while the meal is being eaten, the use of more than one tray requires more space than necessary. In future designs consideration should be given to replacing the trays with a built-in-tray.

Refrigeration:

Some foods were cooled in the refrigerator for further taste appeal. Also, frozen foods were thawed in the refrigerator (fig. 6). The refrigerator functioned satisfactorily throughout the test. Slight sweating occurred in the box, but it is thought that the high humidity of the room in which the test was being conducted was the main cause. Environmental control systems should remedy this.

Can Opener:

The can opener posed only the problem of removing the lids after the cans were opened. The lids were held to the opener by a magnet after being removed from the can, and only one lid could be retained by the magnet at one time. The crewman had to remove the lid from the magnet and place it in the wet storage bin before opening the next can. This process involved many unnecessary moves. The opener should be convenient to the wet storage bin. Also, a means of removing and dispensing of the lid without having to touch it with the hands should be devised.

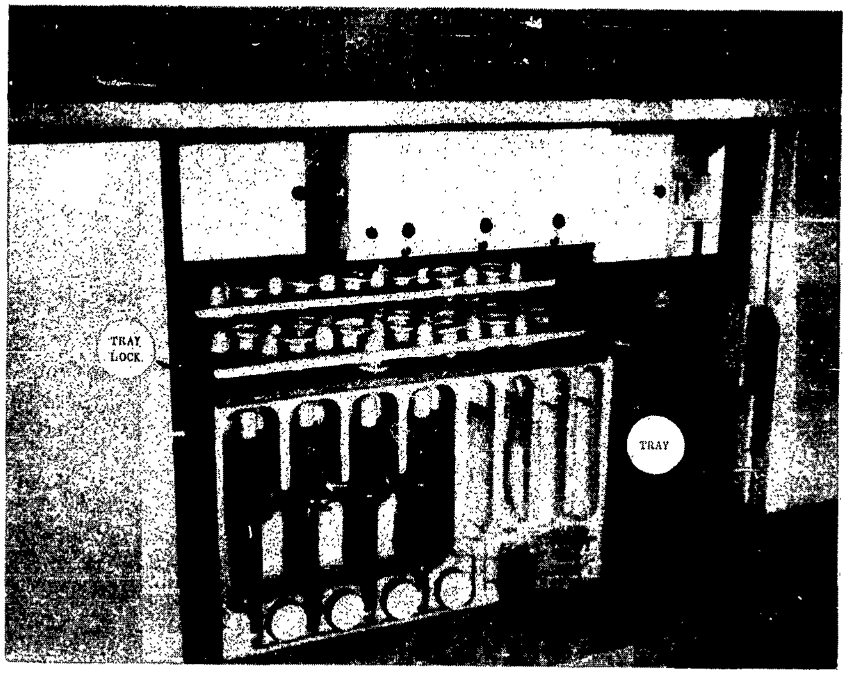
Food Consumption:

The food consumption data multiplied by the caloric density of the given food item provided total daily caloric intake. These data and the body weight data for each subject are graphically represented in appendix III. Although each subject lost weight, the loss cannot be attributed to a lack of food. In most instances not all of the food available was ingested and very little candy was consumed indicating that the subjects were satisfied. One important factor that may account for the weight loss is insufficient water allowance, especially on those days when the ambient temperature was in the high 80's.

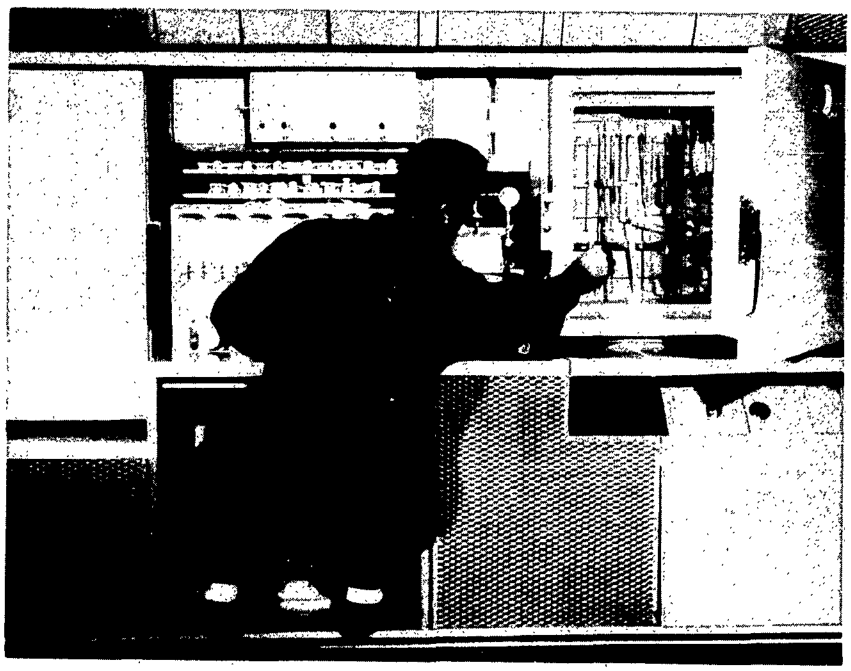
Food Preference:

The mean hedonic rating of each food item as compared to the hedonic rating provided by the QMF&CI is given in appendix IV. These ratings cannot be compared statistically because the number of subjects is too limited, although the number of opportunities afforded each subject to rate a given food item is numerous for certain items such as bread and butter. In general, the following tentative conclusions can be made. The menu, as a whole, is acceptable, although the food preferences of individuals for certain foods should probably be taken into consideration in the menu planning. Fruits and fruit juices are the most appealing. The following foods were reported as needing additional seasoning:

(a) Instant potato
(b) Parsley potato
(c) Steamed rice
(d) Buttered noodles
(e) Scrambled eggs



FEEDING TRAY, EXPELLERS & NIPPLES
Figure 5



REFRIGERATOR
Figure 6

The following foods were reported as having too much seasoning:

(a) Bacon (too salty and too greasy)
(b) Spagetti (too salty)
(c) Tomato soup (too spicy)
(d) Baked apple (too spicy)
(e) Beef with vegetables (too salty)
(f) Candied sweet potatoes (too sweet)

DISPENSING

The test revealed that food dispensing is the area requiring the most improvement. Several major problems arose that must be remedied.

Cans:

The most significant problem was that liquid leaked from the cans. Leaking occurred when the bottom of some cans were cut so the expeller piston could push the foods out of the can. Not all cans leaked. Most leaked slightly, some rather profusely. In a space vehicle, the leaking could not be tolerated. However, the leaking probably would be less severe in a weightless condition because of the absence of force on the liquid. The piston seal must be improved if this arrangement is to work satisfactorily. Seamless cans would be a definite improvement. Aluminum cans of this type are commercially available. Another possible solution would be to package the food inside the can and break the package seal only when the can is opened, thus allowing the package to seal the piston head.

Foods:

Several other minor problems arose while using the cans. When eating canned food, any liquid stored with solid food particles was dispensed first. This made the food less appetizing, and the solid particles became dry and packed in the upper part of the can and nipple. A considerable amount of the food was left in the can because the piston could not drive the food into the nipple. Possibly, in a weightless condition blending of solid and liquid food particles would occur. Regardless, improvement in this area should be made.

Nipples:

Initially the nipples used on the cans had a disagreeable taste; however, the taste was removed after they were cleaned in boiling water. The parting agent used in molding the nipples may have been responsible for the bad taste. The nipples worked very well throughout the test, and proved satisfactory when expelling the food from the cans (fig. 7). They did not leak, and the slit opening allowed both solids and liquids to pass freely, excluding certain foods previously mentioned where packing of solids occurred in the nipple.

Tubes:

The plastic tubes for storing and dispensing food worked satisfactorily (fig. 8). However, it is recommended that the tube opening should be increased to prevent food from jamming in the opening and the method by which food is prevented from escaping from the tubes after they have been opened be changed. The metal clamp is too stiff to allow food to pass easily.

Other:

Bread items, cookies, etc., should be kept to bite size. Crumbs were very easily produced if the food item had to be bitten off. In a weightless environment the crumbs would "float" in the cabin atmosphere. Each item should be small enough to fit in the mouth without further preparation. An edible seal would be ideal for this type of food.

Iodophor:

The iodophor dispenser caused the biggest problem in the disposing process (fig. 9). The valve for injecting the iodophor into used tubes and cans leaked. However, the main valve to the storage tank was closed and the dispensing valve repaired during the test. No problems were encountered when adding the iodophor to used tubes after the repair was accomplished on the valve, unless food, such as rice, was jammed in the opening. If the tube openings were larger or if the duckbill on the iodophor dispenser was longer, no back-flow of iodophor would occur as it did in the test. Often the iodophor would run out of the tube onto the user's hands. A problem also arose when clamping the seal on the plastic tube after the adding of the iodophor. Because of the concentration of the iodophor around the tube opening, squeezing the seal on the tube often caused the iodophor to again get on the user's hands. When iodophor was added to used cans, it was injected through the slit in the nipple. This method proved satisfactory, but there was little or no mixing of the iodophor with the food remaining in the can. Pressure build-up in the can is attributed directly to this nonmixing.

CLEAN-UP

The leaking cans made it necessary for the user to clean not only the expeller, but also his tray and his hands. Commercial Wash-N-Dry towelettes stored in the console were used for this purpose. No more than two packs of towelettes were used by a test subject at one meal. After the meal, each subject was responsible for cleaning his eating utensils and disposing of the food containers he used.

Expellers:

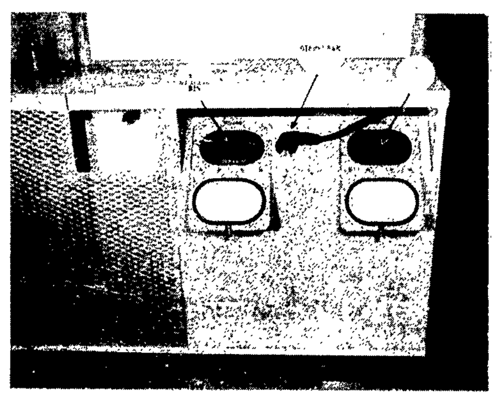
The canned food expellers became quite soiled because of the leaking cans. Consequently, they had to be cleaned, a situation that was not anticipated during the design of the console. The expellers proved quite hard to clean but this cleaning would not be anticipated in actual missions.

FOOD EXPELLING DEVICE

Figure 7

POLYETHYLENE TUBES - STORAGE AND EXPELLING FOODS

Figure 8



FOOD WASTE STORAGE- IODOPHOR DISPENSER

Figure 9

GENERAL DESIGN AND CONCLUSIONS

The authors of this report have gained considerable knowledge and insight into the mechanical problems that may be involved in feeding an astronaut during an aerospace mission. Following are two comments concerning the general design of the console and its components, based upon actual experience with it:

a. The actual space to be used for feeding astronauts can be further minimized. This will involve the integration of the component parts of future consoles with other cabin furnishings.

b. The basic philosophy of simplicity should be further pursued. A weightless condition poses numerous maneuvering problems without adding complicated procedures for food preparation, dispensing, etc. The meals should be simple to prepare.

A joint effort among nutritionists, foods technologists, and engineers will be required to accomplish optimum feeding conditions. There is no doubt that meals such as those used in this test would be highly desirable in space missions. The answer seems to hinge on whether or not pay loads can afford to provide the astronaut with such luxuries.

Appendix I

Menu - 1-Man 14 Days

	Breakfast	Lunch	Dinner
Day 1	C. Stewed Prunes DX. Frosteo's D. Scrambled Eggs F. Pecan Roll DX. Milk DX. Coffee	DX. Chicken Rice Soup C. Beef with Vegetables C. Buttered Beets D. Buttered Noodles F. Bread - Butter F. Pineapple DX. Coffee or Tea	C. Grapefruit Sections C. Veal Steak C. Buttered String Beans DX. Mashed Potatoes F. Bread - Butter DX. Chocolate Pudding DX. Cocoa or Milk
Day 2	DX. Orange Juice C. Ham & Eggs D. Apricots F. Bread - Butter DX. Milk DX. Coffee	C. Fruit Cup C. Chopped Steak C. Buttered Peas C. Baked Potato F. Bread - Butter F. Coconut Squares DX. Cocoa or Milk	DX. Vegetable Soup C. Curried Chicken C. Buttered Carrots DX. Steamed Rice F. Bread - Butter F. Blueberries DX. Coffee or Tea
Day 3	DX. Tomato Juice DX. Oatmeal D. Beef Hash F. Bread - Butter DX. Milk DX. Coffee	DX. Consomme F. Pork with Apples C. Buttered Wax Beans C. Candied Sweet Potatoes F. Bread - Butter F. Raisin Cake DX. Coffee or Tea	DX. Pineapple-Orange Juice C. Swiss Steak C. Buttered Mixed Vegetables C. Parsley Potatoes F. Bread - Butter F. Pears DX. Cocoa or Milk
Day 4	C. Grapefruit Sections D. Scrambled Eggs C. Bacon F. Coffee Cake DX. Milk DX. Coffee	DX. Vegetable Soup D. Spahetti & Meat Sauce C. Buttered Peas C. Pineapple F. Bread - Butter F. Sugar Cookies DX. Cocoa or Milk	DX. Apple Juice C. Baked Ham w/Raisin Sauce DX. Steamed Rice C. Buttered Succotash F. Bread - Butter F. Pound Cake DX. Coffee or Tea
Day 5	DX. Orange Juice DX. Ralston C. Canadian Bacon C. Peaches F. Bread - Butter DX. Milk DX. Coffee	DX. Tomato Juice C. Beef Stew C. Buttered Corn C. Buttered Baby Lima Beans F. Bread - Butter F. Nut Bars DX. Cocoa or Milk	DX. Cream of Mushroom Soup C. Filet of Sole DX. Mashed Potatoes C. Buttered String Beans F. Bread - Butter F. Frozen Strawberries DX. Coffee or Tea

		Breakfast		Lunch		Dinner
Day 6	DX.	Tomato Juice	DX.	Beef Rice Soup	DX.	Grapefruit Juice
	C.	Ham & Eggs	C.	Turkey	C.	Veal Steak
	C.	Pineapple	C.	Buttered Carrots	C.	Buttered Mixed Vegetables
	F.	Sweet Roll	D.	Buttered Noodles	C.	Parsley Potatoes
	DX.	Milk	F.	Bread - Butter	F.	Bread - Butter
	DX.	Coffee	DX.	Butterscotch Pudding	F.	Fruit Bars
			DX.	Coffee or Tea	DX.	Cocoa or Milk
Day 7	DX.	Orange Juice	DX.	Tomato Soup	DX.	Pineapple Juice
	D.	Scrambled Eggs	C.	Roast Beef w/Mushroom Gravy	C.	Chopped Steak
	C.	Canadian Bacon	C.	Buttered Green Peas	DX.	Steamed Rice
	F.	Bread - Butter	C.	Baked Potato	C.	Buttered Corn
	DX.	Milk	F.	Bread - Butter	F.	Bread - Butter
	DX.	Coffee	D.	Fruit Cocktail	F.	Brownies
			DX.	Coffee or Tea	DX.	Cocoa or Milk
Day 8	DX.	Orange Juice	DX.	Chicken Rice Soup	DX.	Grape Juice
	C.	Ham and Eggs	C.	Beef Stew	C.	Swiss Steak
	C.	Peaches	D.	Buttered Noodles	C.	Buttered String Beans
	F.	Bread - Butter	DX.	Applesauce	C.	Candied Sweet Potatoes
	DX.	Milk	F.	Bread - Butter	F.	Bread - Butter
	DX.	Coffee	F.	Coconut Squares	F.	Chocolate Chip Cookies
			DX.	Cocoa or Milk	DX.	Coffee or Tea
Day 9	DX.	Tomato Juice	DX.	Pineapple Juice	DX.	Chicken Noodle Soup
	DX.	Ralston	C.	Veal Steak	C.	Chopped Steak
	D.	Beef Hash	C.	Buttered Mixed Vegetables	C.	Buttered Wax Beans
	F.	Sweet Roll	D.	Mashed Potatoes	DX.	Rice w/Gravy
	DX.	Milk	F.	Bread - Butter	F.	Bread - Butter
	DX.	Coffee	F.	Brownies	F.	Pears
			DX.	Coffee or Tea	DX.	Cocoa or Milk
Day 10	DX.	Orange Juice	DX.	Grape Juice	DX.	Vegetable Soup
	D.	Scrambled Eggs	C.	Beef Steak w/Gravy	C.	Spaghetti & Meat Balls
	C.	Bacon	C.	Parsley Potatoes	C.	Buttered Peas
	D.	Prunes	C.	Diced Carrots	C.	Grapefruit Sections
	F.	Bread - Butter	F.	Bread - Butter	F.	Bread - Butter
	DX.	Milk	F.	Raspberries	F.	Nut Bars
	DX.	Coffee	DX.	Cocoa or Milk	DX.	Coffee or Tea

		Breakfast		Lunch		Dinner
Day 11	DX.	Grapefruit Juice	DX.	Tomato Juice	DX.	Consomme (Beef)
	DX.	Cream of Rice	C.	Veal Steak	C.	Baked Chicken
	C.	Canadian Bacon	D.	Buttered Noodles	C.	Buttered Succotash
	F.	Pecan Roll	C.	Baked Apple	C.	Baked Potatoes
	DX.	Milk	F.	Bread - Butter	F.	Bread - Butter
	DX.	Coffee	F.	Fruit Bars	F.	Blueberries
			DX.	Coffee or Tea	DX.	Cocoa or Milk
Day 12	DX.	Orange Juice	DX.	Vegetable Soup	DX.	Tomato Juice
	C.	Ham and Eggs	C.	Shrimp & Rice	C.	Fish w/Tomato sauce
	C.	Pineapple	C.	Buttered Mixed Vegetables	C.	Buttered Corn
	F.	Bread - Butter	D.	Pears	C.	Buttered String Beans
	DX.	Milk	F.	Bread - Butter	F.	Bread - Butter
	DX.	Coffee	DX.	Butterscotch Pudding	F.	Pound Cake
			DX.	Cocoa or Milk	DX.	Coffee or Tea
Day 13	DX.	Pineapple Juice	C.	Fruit Cocktail	DX.	Chicken Rice Soup
	D.	Scrambled Eggs	C.	Roast Beef w/Mushroom Gravy	C.	Baked Ham w/Raisin Sauce
	C.	Bacon	D.	Stewed Tomatoes	C.	Buttered Baby Lima Beans
	C.	Stewed Apricots	DX.	Mashed Potatoes	C.	Parsley Potatoes
	F.	Bread - Butter	F.	Bread - Butter	F.	Bread - Butter
	DX.	Milk	F.	Sugar Cookies	F.	Strawberries
	DX.	Coffee	DX.	Coffee or Tea	DX.	Cocoa or Milk
Day 14	C.	Grapefruit Sections	DX.	Apple Juice	DX.	Tomato Soup
	DX.	All Star	C.	Beef Steak	C.	Turkey
	C.	Canadian Bacon	C.	Buttered Peas	C.	Buttered Mixed Vegetables
	F.	Coffee Cake	C.	Baked Potatoes	DX.	Rice w/Gravy
	DX.	Milk	F.	Bread - Butter	F.	Bread - Butter
	DX.	Coffee	F.	Raisin Cake	F.	Peaches
			DX.	Cocoa or Milk	DX.	Coffee or Tea

D = Dehydrated
C = Canned
F = Frozen
X = Tubed

FOOD PREFERENCE QUESTIONNAIRE

NAME: **DATE:** **MEAL (Bkfst; Lnch; Dnr; or Other):**

This is a questionnaire to obtain information about certain food items which you consumed. Rate the items consumed on the scale below by circling the number under the words that most nearly describe how much you like or dislike the item.

Item	Amount consumed in units or fraction thereof	SERVED: Hot(H); Warm(W); Cold(C)	Like extremely	Like very much	Like moderately	Like slightly	Neither like nor dislike	Dislike slightly	Dislike moderately	Dislike very much	Dislike extremely	TEMPERATURE: Too(H); OK; Too (C)	SEASONING: Adequate (A); Inadequate (I)
			9	8	7	6	5	4	3	2	1		
			9	8	7	6	5	4	3	2	1		
			9	8	7	6	5	4	3	2	1		
			9	8	7	6	5	4	3	2	1		
			9	8	7	6	5	4	3	2	1		
			9	8	7	6	5	4	3	2	1		

If you so desire, please make additional comments about each food you have consumed. Have you experienced nausea or G.I. upset since last meal?

Quantity of Candy Consumed Since Previous Meal: Gum: # ; Caramels: # ; M&M: # ; Other: #

AMPL Form C-15
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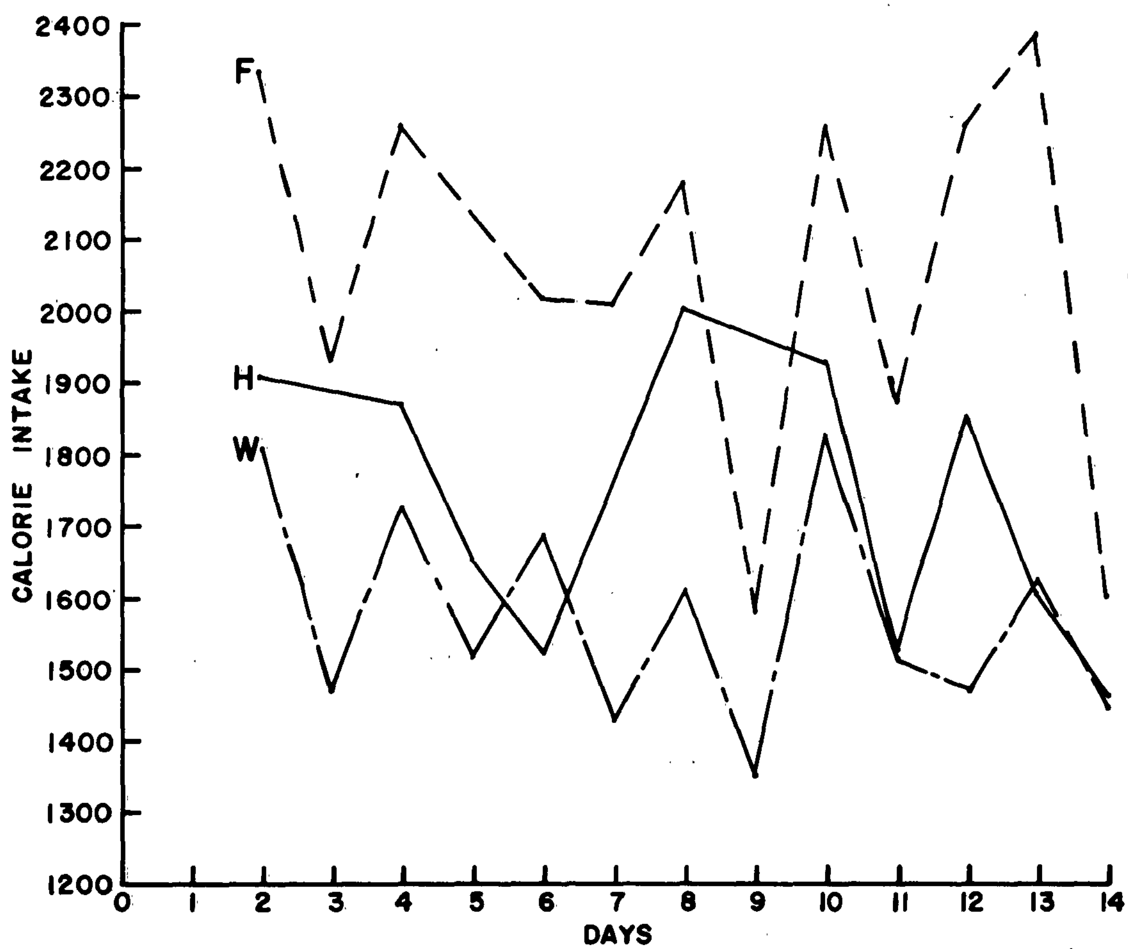
Appendix II

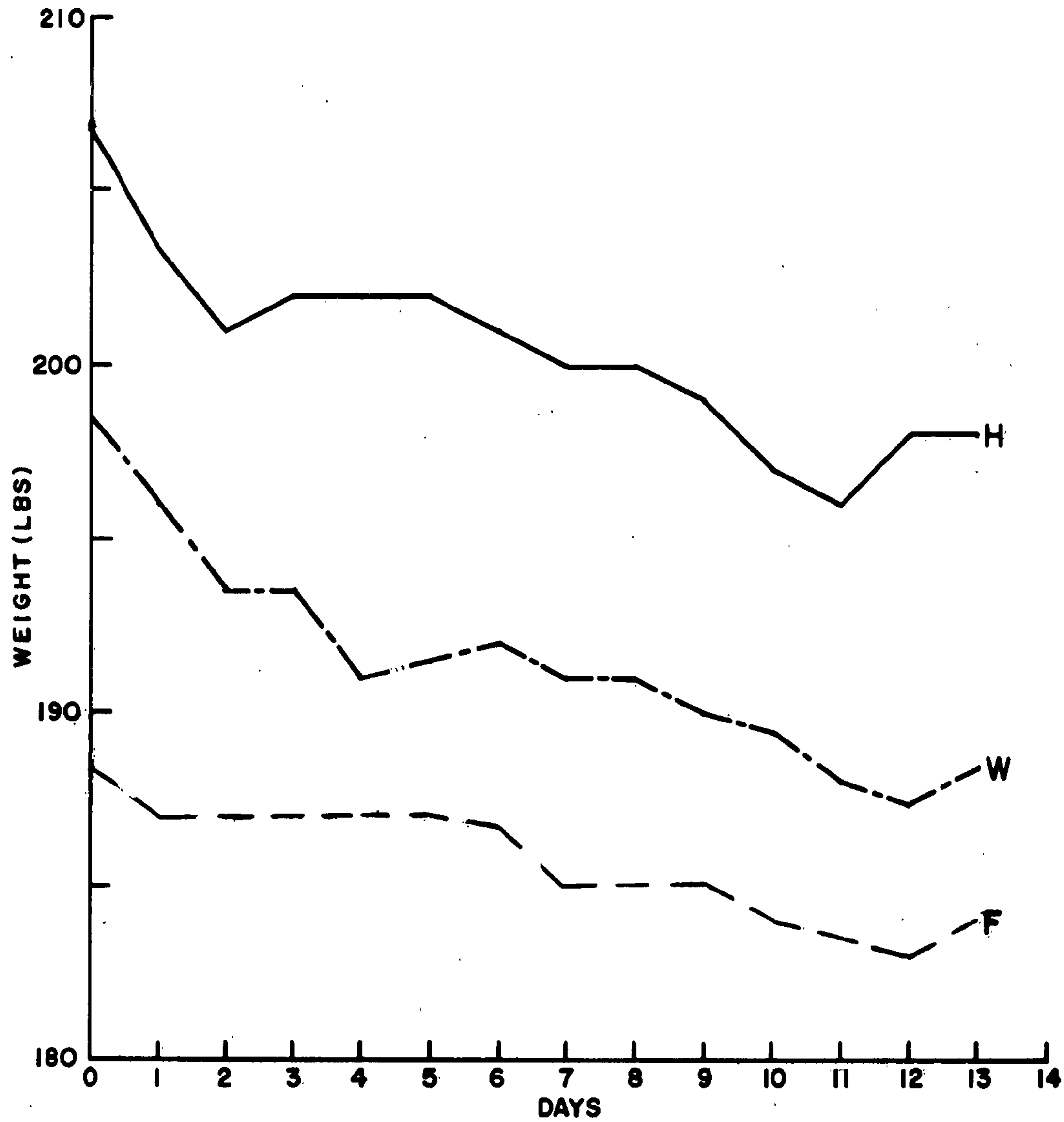
Appendix III

TEST SUBJECTS
CALORIE INTAKE
DURING FEEDING CONSOLE EVALUATION



Appendix III

TEST SUBJECTS
WEIGHT
DURING FEEDING CONSOLE EVALUATION
(weight at first meal of the day)



Appendix IV

Hedonic Rating

Beverages	Known	Found
Cocoa	6.5-7.5	6.9
Coffee	5.0-5.8	6.9
Milk	N/A*	7.7
Tea	N/A	6.0
Juices		
Apple	7.3	8.5
Grape	6.2	8.3
Grapefruit	6.5	8.6
Orange	6.0	7.8
Orange/Pineapple	6.1	8.3
Pineapple	6.4	8.4
Tomato	7.5	7.8
Soup		
Beef Consomme	6.2	7.7
Beef Rice	6.0	7.0
Chicken Noodle	7.0	7.6
Chicken Rice	6.3	7.0
Cream of Mushroom	6.2	6.0
Vegetable	6.3	7.5
Tomato	6.2	7.6
Apple, Baked	N/A	8.3
Apple, Sauce	5.9	8.6
Apricots	6.8	8.0
Blueberries	N/A	8.6
Fruit Cocktail	6.0	8.3
Grapefruit Sections	N/A	8.1
Peaches	6.4	7.9
Pears	6.2	8.1
Pineapple	7.3	8.4
Prunes	6.0	6.8
Pudding, Chocolate	7.1	6.3
Rasberries	N/A	8.6
Strawberries	N/A	8.6
Bacon	6.1	6.9
Ham and Eggs	N/A	7.1
Ham w/Raisin Sauce	N/A	6.5
Pork w/Apple	N/A	7.6
Chicken, Baked	N/A	7.7
Turkey	6.2	7.3
Fish w/Tomato Sauce	6.2	5.6
Filet of Sole	N/A	7.0
Shrimp and Rice	N/A	6.6

Cereals	Known	Found
All Star	4.9	6.6
Frosteo's	6.3	7.0
Cream of Rice	N/A	6.6
Oatmeal	4.9	8.0
Ralston	6.0	7.0
Vegetables		
Beets	N/A	6.0
Carrots	6.6	7.1
Corn	7.2	7.4
Beans, Green	N/A	6.2
Beans, Waxed	N/A	6.6
Beans, Lima	4.7	4.7
Peas	6.5	6.4
Potatoes, Mashed (instant)	5.5	5.9
Potatoes, Baked	N/A	6.7
Potatoes, Parsley	N/A	6.7
Potatoes, Sweet	5.9	7.1
Succotash	N/A	6.7
Tomatoes (stewed)	N/A	6.0
Vegetables, Mixed	N/A	6.5
Noodles	5.9	5.7
Rice, Plain	N/A	4.9
Rice, w/Gravy	6.2	6.8
Pudding, Butterscotch	7.3	7.4
Brownies	N/A	7.6
Cookies, Choc. Chip	N/A	8.0
Cookies, Fig Newton	N/A	7.5
Cookies, Macroon	N/A	7.3
Cookies, Pecan	N/A	7.5
Cookies, Sugar	N/A	7.3
Cake, Pound	N/A	8.0
Cake, Raisin	N/A	7.3
Coffee Cake, Cinnamon	N/A	7.9
Coffee Cake, Pecan	N/A	7.6
Coffee Cake, Sweet	N/A	7.6
Bread and Butter	N/A	6.3
Spaghetti w/Meat Balls	N/A	6.6
Beef Hash	6.1	5.6
Beef w/Gravy	6.4	7.3
Beef w/Vegetables	N/A	7.4
Steak, Chopped	N/A	7.5
Steak, Swiss	6.4	7.3
Veal	7.1	6.7
Eggs, Scrambled	5.9	6.2

* Not available

Appendix V

BACTERIAL ANALYSES OF WATER FROM THE COMPACT FEEDING CONSOLE

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Biospecialties Section

The Compact Feeding Console was designed to furnish those items of hardware necessary for the nutritional and hygiene support of three men for a duration of fourteen days under zero gravity conditions (1). Part of this system is a water storage unit which supplies both hot and ambient temperature water. This unit consists of three anodized cast aluminum chambers and employs silcone rubber bellows to pressurize the water.

The ultimate use of the console will include the recycling of water, i.e., the use of water recovered from urine and waste water. Needless to say, the possibility of microbial contamination of such recycled water must be considered, and methods to eliminate this hazard must be incorporated in any water recovery system design. The initial check-out of the console will not be a closed system study but is contemplated only as a test of hardware and equipments. Since the water storage system is to be charged with a known potable water supply, a bacteriological evaluation of the keeping qualities of the water was considered necessary to provide the baseline for contamination levels for future studies on the quality of the recycled water.

MATERIALS & METHODS:

To insure the initial potability of the water to be used, a supply of prepared drinking water was obtained from the Crystal Water Co., Dayton, Ohio. This water is treated to remove all suspended solids, dissolved chlorine and is passed through a water softener to completely remove all hardness. Bacterial counts are thus minimal. The reservoir was purged several times with this water by means of direct connection to the inlet pump. The transfer pump was not used. Sterile precautions were not taken during the first run, i.e., water was added to the system and withdrawn as required, samples being taken from both hot and cold outlets.

Aliquots of the samples were plated on standard bacteriological media. Ten ml aliquots were added to 30 ml Lactose broth (17.3g/L) and to 30 ml Phenol Red Lactose Broth. Aliquots of 1.0 ml and 0.1 ml were seeded into petri dishes. Both Trypticase Soy (TS) Agar (BBL, 2) and Desoxycholate Agar (BBL) were used for these 1.0 and 0.1 ml portions. For additional dilutions, samples were diluted in TS broth and dropped on TS agar pour plates using the dropping pipette technic. This gave a total dilution range of 10 ml sample to 10^{-4} ml. Samples of 0.1 ml and 0.01 ml were also tested on EMB (BBL) agar. All readings were made after 48-hour incubations at 98°F. Positive and negative controls of all media were included in the study. The pH of the samples was determined with the Cambridge Model R pH Meter.

During the test period, the hot water chamber was heated to 170°F for three hours on various days. Under actual conditions, this chamber will be continually heated; however, for the purposes of this test, it was felt that periodic heating would be sufficiently representative.

At daily intervals several hundred ml were removed from each chamber. This served to simulate the washing of the pump outlets as would occur during use. For the bacterial analyses, 100 ml were pumped from each chamber into sterile screw-capped bottles. At the beginning of each test, a control sample of water was removed aseptically from a freshly opened carboy of water. Plating of the samples was performed immediately.

RESULTS:

The results of the first trial are shown in table 1 . Surprisingly, the control, i.e., the water prior to addition to the reservoir, proved to be sterile. At 0 time, i.e., immediately after the water had been pumped into the chambers, contamination of the system was observed. As is indicated good growth occurred in both Lactose broths without the formation of acid or gas, thus showing the absence of lactose fermentors. The degree of contamination was low but of importance is the fact that organisms capable of growth on EMB were observed. The pH change was probably due to material contamination of the water. After 24 hours a small drop in pH had occurred.

Examination of the EMB and Desoxycholate plates of the 2nd day showed the presence of enteric type organisms. Although gas production in lactose broth was not observed, the heavy growth on Desoxycholate (pink to red subsurface colonies) suggests enteric but non-coliform types. Gram strains revealed the organisms to be slender gram negative rods, as would be expected. Because of this contamination, the test was terminated.

To eliminate the problem of internal contamination, a sterilization procedure was utilized. After the chambers had been emptied of the test water, they were filled with fresh Crystal water containing 1:1000 benzalkonium chloride. This solution was kept in the chambers for 3 hours, after which thorough flushing was initiated. Six complete changes of Crystal water were used to wash out the chambers.

The reservoir was then filled with fresh Crystal water. Heat was applied to the hot water chamber on 5 separate days for 3 hours during the 14-day test period. Samples were taken aseptically on the fifth, ninth, and fourteenth day. The results are shown in table 2.

The control sample on this trial did show very slight bacterial content. This, however, is quite acceptable. The eight colonies observed on the EMB plate for the cold 0 time sample suggest air contamination of the supply during filling of the reservoir. Certainly the sterilization procedure should have been sufficient to eliminate gram negative types (organisms capable of growth on EMB). The degree of contamination observed on the 5th day seems somewhat lessened. Particularly noticeable is the apparent sterility of the hot water sample, which continues to be sterile through the remainder of the test period. On the ninth day, the TS agar counts gave a value of $29 \times 10 = 290$ and $6.6 \times 10^2 = 660$ for an average of 475 bacteria per ml. On the 14th day this is somewhat elevated. Of importance is the appearance of large numbers of organisms on EMB and Desoxycholate agars. The fact that these counts, at least the EMB, were higher than the TS agar counts cannot be explained. Normally one would expect any cells capable of growth on EMB should also grow on TS. Two types of colonies were observed, one large and the other pinpoint. Gram stains again revealed gram negative organisms, the smaller colony consisting of larger (appr. .5 x 2u) cells (large colony cells were appr. .5 x 1u).

DISCUSSION:

The lack of any evidence of bacterial contamination from the hot water samples indicates that the heating conditions are sufficient to sterilize the contaminated water. Since only gram negative organisms were observed, this is consistent with the known heat stability of enteric types of bacteria. The growth or increase in the contamination level, as can be seen from the 5 to 14 day counts, suggests the presence of some organic substance or at least some materials which enable bacterial growth. Since the Crystal water used to fill the reservoir is quite free of most substances (probably high levels of Na are present from the softening process), material contamination must have been introduced by the system itself.

The presence of organisms capable of growth on Desoxycholate agar is indicative of enteric organisms. Although lactose was not fermented, several enteric types might still be considered, viz., Salmonella, Shigella, Providence group, and Proteus. These are, of course, predominantly pathogenic types and are certainly not involved here. However, the water, although still considered potable, would not have a long acceptable detention period. Undoubtedly the source of these organisms was air contamination gaining entrance to the reservoir via the inlet valve.

CONCLUSIONS:

1. The construction of the chambers should be such that internal cleaning with detergents is possible.

2. For future studies in which the water will be consumed, the use of Halazone tablets or the newer iodides is strongly recommended.

3. Rigorous disinfection of the water reservoir should be accomplished prior to each test. The use of long contact times with benzalkonium chloride, 1:1000, is recommended.

TABLE 1

BACTERIAL ANALYSIS OF CFC WATER SUPPLY FIRST TRIAL

TIME, DAYS.............		0	0		1		2	
<u>MEDIUM</u>	<u>DILUTION, Ix</u>	<u>CONTROL</u>	HOT	COLD	HOT	COLD	HOT	COLD
TS Agar	10^{-1}	0	6	Cont				
	10^{-2}	0	<1	1				
	10^{-3}	0	0	0				
EMB Agar	10^{-1}	0	0	4			3*	3*
	10^{-2}	0	0	<1	N			
Desoxycholate	10^{-0}	0	0	1		D	4*+	4+
	10^{-1}	0	0	0				
Lactose Broth	10^{-1}	neg	3+	3+				
Pehnol Red Lac. Broth	10^{-1}	neg	2+	2+				
pH		9.4	8.5	8.8	8.2	8.3		

neg - negative
4+ growth in broth is maximum
cont. - plate contaminated
A - Acid
G - Gas
ND - not determined
* Qualitative observations recorded only for these since water contamination is indicated.

TABLE 2

BACTERIAL ANALYSIS OF CFC WATER SUPPLY
SECOND TRIAL

TIME DAYS		0	0		5		9		14	
MEDIUM	DILUTION, 1x	CONTROL	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold
TS Agar	10^{-1}	0	0	0	0	0	0	29	0	45
	10^{-2}	0	0	0	0	0	0	6.6	0	cont
	10^{-3}	0	0	0	0	0	0	< 1	0	cont
EMB Agar	10^{-1}	1	0	8	0	2	0	0	0	491 large 57 small
	10^{-2}	0	0	0	0	0	0	0	0	6.6 large
Desoxycholate Agar	10^{-0}	0	0	0	0	0	0	0	0	128
	10^{-1}	0	0	0	0	0	0	0	0	10
Lactose Broth	10^{-1}	3+	3+	3+	neg	2+	neg	+	neg	3+
Pehnol Red Lac. Broth	10^{-1}	A	A	A	neg	+	neg	+	neg	2+
pH		9.5	no	no	8.5	8.3	8.6	8.8	8.5	8.7

neg - negative
cont - plate contaminated
4+ growth in broth is maximum
A - Acid
G - Gas

REFERENCES

1. Brehm H. E., 1961. Compact Feeding Console Design, Fabrication, and Evaluation. ASD Technical Report 61-569.

2. Products for the Microbiological Laboratory, 4th Edition. Baltimore Biological Laboratory, Inc., Baltimore, Maryland.