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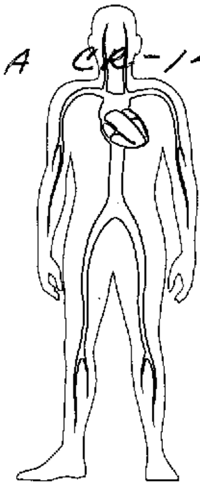

TECHNOLOGY INCORPORATED
LIFE SCIENCES DIVISION

FINAL REPORT

1 October 1968 to 31 January 1973

Contract NAS 9-8927

FLIGHT FEEDING SYSTEMS DESIGN AND EVALUATION

National Aeronautics and Space Administration
Johnson Space Center
Houston, Texas 77058

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FINAL REPORT

PERIOD 1 OCTOBER 1968 TO 31 JANUARY 1973
CONTRACT NAS 9-8927

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FLIGHT FEEDING SYSTEMS DESIGN AND EVALUATION

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APPENDIX

1.0 INTRODUCTION

This Final Report is submitted in compliance with Contractual Agreement NAS 9-8927 and covers the period 1 October 1968 to 31 January 1973. Each task accomplished during the contract is briefly discussed and sources of detailed descriptions are included for reference. Tasks which involved support of the late Apollo missions, i.e., Apollo 16 and Apollo 17, are emphasized in the discussion.

2.0 WORK ACCOMPLISHED

2.1 Apollo In-flight Menu Design

Menu design support was provided for the Apollo missions 8-17. In-flight menus and pertinent information for the Apollo missions are included in Tables 1 through 46.

Menus were planned to contain 2200 $\pm$ 300 calories for Apollo missions 7 through 15 using 4 or 5 items per meal including beverages.

A report of the Apollo 14 food system was published in *Aerospace Medicine, 42*:1185-1192 (see Appendix A).

The Apollo 16 menu was unique in that it was designed to measure input and output of selected minerals and electrolytes. Beverages were fortified with potassium in the form of potassium gluconate to bring the level of potassium in flight menus up to 140 mEq per day. Flight menus for the Apollo 17 mission were designed to provide specified daily levels of certain nutrients as follows:

Nutrient	Daily Requirement
Protein	90 - 125 g
Calcium	750 - 850 mg
Phosphorus	1500 - 1700 mg
Sodium	3000 - 6000 mg
Magnesium	300 - 400 mg
Potassium	(at least 3945 mg)

Elevated potassium intakes were achieved through the use of potassium gluconate supplementation of some beverages, but supplementation did not exceed 30 mEq of potassium per day.

Energy requirements for both the Apollo 16 and 17 crews were estimated for each crewman according to the formula suggested by the Food and Nutrition Board of the National Research Council[a] for the adjustment of calorie allowances for adult individuals of various weights and ages (at a mean environmental temperature of 20°C (68°F), assuming light physical activity). The calculated daily energy level for each crewman was:

Flight	Crewman	Calories
Apollo 16	John Young, CDR	2750
	Charles Duke, LMP	2650
	Ken Mattingly, CMP	2500
Apollo 17	Eugene Cernan, CDR	2870
	Ronald Evans, CMP	2740
	Harrison Schmitt, LMP	2800

[a] National Academy of Sciences, Recommended Dietary Allowances, Seventh Revised Edition, 1968, p. 5.

The energy level of each menu was adjusted according to the estimated requirements of each crewmember. This requirement was verified by a 6-day ground-based metabolic test for the Apollo 17 crew. Flight diets contained approximately 300 calories less than the established ground-based requirements.

To assist in menu design, an individual file was compiled for each astronaut. This file contained food preference data (each astronaut was permitted to taste samples of flight food and indicate preference on a 9-point hedonic scale), postflight data, and information obtained from personal interviews with both astronauts and the astronauts' wives. The information was helpful in ascertaining food preferences, eating habits, and possible allergies or digestive peculiarities.

With few exceptions (Apollo 8, Apollo 15, and LM menus for Apollo 9-15) different menus were designed for each individual crewmember. Preliminary menu design was reviewed by each astronaut and recommended modifications submitted to the dietetic staff. Final menu design was approved and signed by each astronaut.

2.2 Food System for Pre- and Postflight Periods

Food systems were designed to satisfy specialized requirements. This included systems for post-lunar quarantine, and pre- and postflight periods for the later Apollo missions.

A food system was designed for the Mobile Quarantine Facility (MQF) which was utilized during the initial recovery period of post-lunar quarantine. The MQF was deployed on the prime recovery ship in support of Apollo 11, 12, 13[b], and 14. Astronauts were confined in the MQF immediately after recovery and transferred to the Lunar Receiving Laboratory, Houston, Texas.

The MQF was equipped with a microwave oven (Amana Model RR-1), and precooked frozen foods were selected as the basic menu components for the MQF feeding system. Foods and packaging concepts were designed which were compatible with the microwave oven. Frozen foods were supplemented with beverages and snack items. MQF menus used for the Apollo 11 mission and a description of this food system are included in the Annual Progress Report (1 October 1968 to 30 September 1969). Production Guide for MQF Food Procurement is included in Supplement 1. MQF menus for Apollo 12 were similar to those designed for Apollo 11, except that a 5-day menu cycle was used for Apollo 12, instead of a 4-day cycle (see Quarterly Report, 1 October 1969 to 31 December 1969). The Apollo 13 MQF food system and menu is described in the

[b] Because of the in-flight explosion on Apollo 13, which aborted the planned lunar landing, the astronauts were not quarantined.

the Quarterly Report (1 January 1970 to 31 March 1970). The MQF food system and menu for Apollo 14 is included in the 1970 October through December Quarterly Report.

Although the MQF was not deployed for the Apollo 15 mission, MQF type menus were designed for use on the recovery vessel for the initial postflight period (see Quarterly Report, April through June 1971). Similar systems were designed for Apollo 16 (see Quarterly Report, January through March 1972), and Apollo 17 (see Quarterly Report, October through December 197

Food systems were also designed for the post-lunar quarantine in the Lunar Receiving Laboratory, NASA-MSC, for Apollo 11-14. More flexibility was permitted in this system than the MQF feeding plan because chefs were available to prepare food for personnel quarantined in the LRL. In addition, the LRL was adequately equipped with a variety of food storage and preparation equipment.

Basically, the system was composed of precooked frozen foods, which were supplemented by fresh produce, beverages and canned items. The menus which were developed for the LRL quarantine are included in the Quarterly Report for October through December 1969. Similar systems were designed for Apollo flights 12-14. Food Handling Procedures for the Crew Reception Area in the LRL were documented and are included in Appendix B. The Production Guide for Frozen Food Utilized in the LRL is contained in Supplement 1, Final Report.

For Apollo 16, nutrient intake was measured and urine and fecal samples collected at KSC 3 days prior to launch and 3 days postflight on the recovery ship "USS Ticonderoga." A complete balance of specified minerals and electrolytes along with analytical values were reported in April through June 1972 Quarterly Report.

Apollo 17 astronauts were also on a controlled diet 3 days prior to launch and 3 days after recovery. Fecal and urine samples were collected during the test periods and nutrient intake documented. Metabolic balance data were reported in the October through December 1972 Quarterly Report.

2.3 <u>Apollo In-flight Nutrient Intake</u>

Average daily nutrient intakes for astronauts during the Apollo 7 through 17 missions are presented in Table 47. Consumption levels were determined for the following nutrients: calories, protein, fat, carbohydrate, ash, calcium, phosphorus, iron, sodium, potassium, and magnesium.

2.4 <u>Nutrition Systems for Pressure Suits</u>

Nutrition systems were successfully developed in the Apollo Program for astronauts wearing pressure suits during emergency decompression situations and during lunar surface explorations. These nutrition systems consisted of unique dispensers, water, flavored beverages, nutrient fortified beverages, and intermediate moisture food bars. The emergency decompression system dispensed the nutrition from outside the pressure suit by interfacing with a suit helmet penetration port. The lunar exploration system utilized dispensers stowed within the interior layers of the pressure suit. These systems could be adapted for provision of nutrients in other situations requiring the use of pressure suits.

A manuscript (see Appendix C) describing this system has been prepared for publication in *Aerospace Medicine*.

2.5 Food System for Project Tektite

Tektite II, a joint project sponsored by the Department of the Interior and the National Aeronautics and Space Administration commenced 1 April 1970 at Lameshur Bay, St. John, Virgin Islands. Two undersea stations, a large habitat and a mini-habitat, were to be deployed in a series of underwater experiments. A food system was developed for Tektite Dives 2, 3, 4, 6, 8, 9, 10, 11, and 12.

The large habitat was deployed for Dives 2, 3, 4, 6, 8, 10, and 12 (50 foot depths). The crew complement for the large habitat consisted of 5 individuals (1 engineer and 4 scientists). Dives 2, 3, and 4 were conducted as a series. Collectively, the dives spanned a 60-day period. The second 60-day mission included Dives 8, 10, and 12. For the 60-day missions, the scientists were rotated every 20 days, and the engineer was rotated every 30 days. Dive 6 was a 14-day mission and the subjects were all females. The female crew was changed at the conclusion of the 14-day period with no rotation during the mission.

The mini-habitat was to be placed at a depth of 100 feet for Dives 9 and 11. Two individuals (a scientist and an engineer) were to be confined in the mini-habitat. The length of each dive would have been 14 days with crew change at the conclusion of the 14-day period, however, problems were encountered with the mini-habitat and it was never deployed.

Precooked frozen foods formed the core of the first 60-day mission (Dives 2, 3, and 4). The frozen food was supplemented with snack foods and beverages.

The food system for Dives 6, 8, 9, 10, 11, and 12 was similar to that designed for Dives 2, 3, and 4 except that several freeze-dried and thermostabilized foods were integrated into the system.

The aquanauts were requested to indicate their preference for each item consumed on a 9-point hedonic rating scale.

The Tektite crews were debriefed at the conclusion of each dive whereby additional information regarding food monotony and eating habits was obtained.

A study was also initiated wherein the energy expenditure or caloric output of the aquanauts was measured through the use of distal, visual observation. Energy expenditure, based upon activity, was correlated with food or caloric intake.

Menus for Tektite II are included in Quarterly Reports, January through March 1970, and April through June 1970.

2.6 Product Development

Product or package development projects completed during the contract period included freeze-dried rice, chicken rice soup, in-suit food bars, potassium fortified beverages, bread, pecans, dried fruits (apricots, peaches and pears), freeze-dried soups (Romaine, seafood bisque, crab mushroom, and sea scallop bisque), frozen sandwiches, space food bars, beef jerky, instant orange juice, chocolate bars, peanut flavored chocolate bar, instant grits, frésh fruits, ice cream, and frozen meals for the in-flight food system.

2.6.1 Freeze-Dried Rice

A United States Patent (No. 3, 692, 533) was issued on September 19, 1972, on the Modification of the Physical Properties of Freeze-Dried Rice. A copy of this patent is included in Appendix D. Freeze-dried chicken and rice soup was developed and utilized as a component of the Apollo Food System commencing with Apollo 13.

2.6.2 In-suit Food Bars

In-suit food bars were developed for utilization in the Apollo space suit while the astronauts were on the lunar surface. The bars were composed primarily of natural fruits, gelatin, sugar and water. Seven varieties of bars were developed (apricot, cherry, plum, raspberry, lemon, strawberry, and spiced apple). The bars were designed to be stable at room temperature by adjusting their equilibrium relative humidity (water activity) to 65 percent (i.e., they would neither gain nor lose moisture in an environment of 65 percent relative humidity). This condition inhibited microbiological growth. Each bar was covered with an edible starch film to prevent the product's stickiness from interfering with release of the bar from the food dispenser. The edible film was consumed along with the bar.

After wrapping the food bar in the edible starch film, it was inserted into an elastic nylon food dispenser. Velcro patches were attached to the nylon for anchoring the dispenser and bar to the fluid dispenser and the neckring of the pressure suit. (More information is included in Appendix C).

2.6.3 Potassium Supplementation

A medical requirement was levied for an increased level of potassium (K) in the diet of the Apollo 16 crew during flight and for 72 hours both pre- and postflight. The level of potassium intake was recommended to be 140 mEq per day per crewman. Attempts to satisfy this requirement in designing flight menus were not successful utilizing available flight foods. Pre- and postflight menus utilizing frozen preplated foods from a commercial source also did not provide 140 mEq K per day. Therefore, the possibility of K supplementation through the use of chemicals was investigated. The following potassium compounds which may be used as food additives were added to black coffee at the level of 15 mEq per serving and taste tested:

Potassium Iodide	Potassium Phosphate
Potassium Bromate	Dipotassium Phosphate
Potassium Iodate	Potassium Chloride
Potassium Citrate	Potassium Gluconate

Potassium iodide, bromate, iodate, and chloride possessed objectionable flavors when mixed with black coffee. Potassium bromate and iodate also did not readily go into solution. Potassium citrate did not produce any serious off-flavors, but it was deleted from the list of candidate chemicals because it may be diuretic if consumed in quantities greater than 2 grams. In order to maintain a K intake level of 140 mEq, it was necessar to consume quantities of potassium citrate in excess of 2 grams.

Several candidate Apollo foods and possible potassium compounds were evaluated by a technical taste panel. Potassium gluconate and citrate received the highest mean rating compared with the other potassium compounds.

Triangle tests were conducted with potassium gluconate added to various beverages and soups. Panel members were asked to identify which beverage or soup was different from the other two.

Taste evaluations revealed 3 potential potassium compounds suitable for supplementation into the Apollo diet. These compounds were potassium citrate, potassium gluconate, and dipotassium phosphate.

Dipotassium phosphate does not require as much chemical per serving as potassium gluconate (0.87 grams compared to 2.35) to obtain 10 mEq of potassium. However, dipotassium phosphate was more readily detectable by expert taste panelists. The difference in taste was not usually objectionable; however, one panelist found it to be very objectionable when added to cocoa.

The difference in acceptability of dipotassium phosphate and potassium gluconate could be attributed to differences in pH. A 10 mEq solution of dipotassium phosphate has a pH of 9.1 compared to a pH of 7.4 for potassium gluconate. Ten mEq of dipotassium phosphate increased the pH of orange drink from

3.2 to 4.0 while 10 mEq of potassium gluconate increased the pH to 3.6. Potassium gluconate consistently received the highest rating when compared to other potassium salts. With the exception of pea soup, the samples containing potassium gluconate were "undistinguishable" from other soups. These foods are more highly buffered and, therefore, less subject to change in pH.

A literature survey on the use of potassium compounds as food additives revealed that there was a significant increase in the occurrence of circumferential ulcerating, stenotic lesions of the small bowel in the mid 1960's in patients on potassium therapy. However, this has been attributed to the use of potassium chloride in tablet or concentrated form.[1,2,3,9] No unfavorable effects from the use of potassium gluconate in healthy individuals were suggested in standard drug use references.[1,4,6,7,8] Potassium gluconate was reported to be a very non-irritating, biologically active potassium compound.[2] It is a normal intermediary metabolite which is readily absorbed and produces no evidence of ulcerations at a dosage level of 80 mEq per day.[5] The suggested usual dosage is the equivalent of 10 mEq of K 4 times daily.[1,4,5,6,7,[illegible] 10]

Based upon these studies, it was recommended that some Apollo 16 beverages and possibly soups be supplemented with 10 mEq K as potassium gluconate. This was accomolished by the addition of 2.35 grams potassium gluconate per serving.

It was recommended that grape drink, orange drink, pineapple-orange drink, pineapple-grapefruit drink, grapefruit with sugar and cocoa be supplemented with potassium gluconate. If the required potassium level could not be obtained by the use of these enriched beverages, then certain soups could be enriched. Two sources of N.F. grade potassium gluconate were located. These were Pfizer Chemicals Division[c] and Warren-Teed Pharmaceuticals Incorporated[d].

Over 250 individual servings of Apollo beverages were supplemented by the addition of potassium gluconate in the Food and Nutrition Laboratory. This included Apollo 16 flight beverages, as well as pre- and postflight beverages, plus backup and contingency supplies, and samples for a bedrest study in San Francisco.

Fortified beverages were also used on the Apollo 17 mission. Potassium gluconate supplementation of beverages on Apollo 17 did not exceed 10 mEq of potassium per serving.

Potassium supplementation of food with potassium gluconate was submitted as a new technology report. This new technology may have broad applications in medical and nutritional areas.

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[c] Pfizer Chemicals Division, P.O. Box 22249, Dallas, TX 75222.

[d] Warren-Teed Pharmaceuticals, Inc., 582 West Goodale Street, Columbus, OH 43215.

2.6.4 Bread Packaging

A concept was developed for packaging fresh bread which would provide shelf-life of at least 2 weeks. Material selection was based upon low moisture and gas transmission rates and heat sealability.

Three types of bread - white, whole wheat, and rye - were initially packaged in a mylar-polyethylene laminate. The packages, each containing 1 slice, were flushed 3 times with nitrogen, partially evacuated (3 to 4 inches Hg) and heat sealed.

Three samples were tested for ultra-high vacuum compatibility. The sealed packages were placed in an AVCO environmental chamber and the chamber evacuated to 1×10^{-6} torr. The packages were removed and examined after a 15-minute holding period. The packages were returned to the chamber and it was again evacuated to 1×10^{-6} torr. The packages remained at this pressure for an additional 15 minutes. Two of the 3 packages burst during the second 15-minute period. The slices of bread in the ruptured packages were dehydrated and extremely hard.

Two additional packages of bread were placed in a chamber and evacuated to 5 psia. The packages ballooned but did not burst.

Additional samples of rye, white and cheese bread were packaged in KEL-F-82 and placed in chambers which were evacuated to very low pressures. These packages did not burst under these low pressure conditions. An attempt was made to evacuate the chamber to 1×10^{-6} torr, but this pressure was not attained because of the degree of off-gassing. Apparently there were pinholes in the packaging material.

Storage studies have been conducted with bread packaged in the following materials: 1) a mylar-polyethylene laminate, 2) a polyethylene-mylar-aclar-polyethylene laminate (SLP-4), 3) KEL-F-82. The packaging material was swabbed with 70 percent ethyl alcohol. The individual slices of bread were placed asceptically into the package. Each package was flushed 3 times with nitrogen, partially evacuated and heat sealed.

The studies established two important facts. First, if the bread is handled and packaged asceptically, flushed with nitrogen and partially evacuated, mold growth can be controlled for several weeks. Samples of bread have been stored for 14 weeks without the development of mold growth. Second, if water vapor and gas transmission rates of packaging materials are low, the bread remains soft and fresh.

Bread packaged for Apollo flights were handled and packaged according to T.I. Production Guide No. 005 (see Supplement 1, Final Report). A new technology report was submitted for this packaging innovation.

2.6.5 Pecan Packaging

A package system was developed for pecans. Detailed procedures for handling and packaging pecans are included in T.I. Production Guide No. 011 (see Supplement 1, Final Report).

2.6.6 Dried Fruit Packaging

A package was designed for dried fruits (apricots, peaches, and pears). Procedures for packaging dried fruits are included in T.I. Production Guide No. 009 (see Supplement 1, Final Report).

2.6.7 Freeze-dried Soups

A variety of soups were freeze-dried and included in the Apollo Food System. Freeze-dried soups included romaine, seafood bisque, crab mushroom, and sea scallop bisque. Procedures for drying and packaging the products are included in T.I. Production Guide No. 017 (see Supplement 1, Final Report)

2.6.8 Frozen Sandwiches

Frozen sandwiches were developed for utilization during the initial periods of the Apollo flights. Sandwiches (ham, ham and cheese, or sliced smoked turkey) were packaged under strict sanitary conditions and frozen. Immediately prior to flight, the frozen sandwiches were inserted into a suit pocket. These products were consumed during the initial flight period.

~~2.6.9~~ Miscellaneous Package Development

Packages were designed for space food bars, beef jerky, instant orange juice, chocolate bars, peanut flavored chocolate bars, and instant grits. Procedures for handling and packaging these products are included in production guides (see Supplement Final Report).

2.6.10 Frozen Food

Although never utilized in the Apollo Program, a frozen food capability was developed. Procedures were developed to include ice cream and frozen meals. Prototype articles were developed and evaluated. Production guides for ice cream and frozen meals were documented (see Supplement 1, Final Report). Ice cream and frozen meals were to be stored in a static freezer (liquid nitrogen cooled) and subsequently consumed in-flight. An Apollo food warming tray was developed under another contract for heating the frozen meals.

Because of weight and volume restrictions, this system was not implemented in the Apollo Program.

Additional information on this project is contained in the Annual Progress Report (October 1968 through September 1969).

2.6.11 Fresh Fruit Packaging

An investigation was undertaken to determine the feasibility of providing fresh fruit for spacecraft feeding. Three series of tests were performed to determine the effect of reduced pressure, storage temperature, and oxygen atmosphere on both packaged and non-packaged fruit.

Apples, bananas and oranges were placed in an AVCO environmental chamber and the pressure was reduced to 1×10^{-6} torr for a 24-hour period. Out-gassing was extensive and excessive moisture contaminated the vacuum system. The fruit samples became dehydrated when subjected to this low pressure environment. To eliminate the adverse effects of dehydration, a package was designed to retard out-gassing and moisture loss.

Packaging materials with low oxygen and water vapor transmission rates were selected.

Four apples and 2 oranges were packaged in SLP-4 and sealed under vacuum. The internal pressure of the packages was 50 mm of Hg. Two varieties of apples, Rome Beauty and Delicious were packaged. These samples, along with non-packaged samples were placed in a chamber at 5 psia. The chamber temperature was 22.2°C throughout the test.

After 7 days, one packaged apple from each variety and 1 packaged orange was removed from the chamber and examined. The Rome Beauty apple was discolored and 90 percent of the mass was soft and watery. The packaged Delicious apple showed no change during this period. The Delicious apple was firm and in an acceptable condition. The packaged orange was unchanged except for some mold at the stem.

The non-packaged Rome Beauty apple was slightly withered showing signs of some dehydration. The non-packaged Delicious showed no apparent change in its physical condition. There was little or no difference between the appearance of the packaged and non-packaged Delicious apples.

Out-gassing in the packaged Delicious apple was slight but out-gassing in the packaged orange and the packaged Rome Beauty apple was extensive.

Two conclusions were drawn from these preliminary tests. First, the Rome Beauty apple is an undesirable variety and future evaluations should include the Delicious variety. Second, unpackaged fruit is subject to dehydration under low pressures.

A preliminary storage test was conducted with apples, bananas, and oranges packaged in SLP-4 and non-packaged samples of these fruits. Each package was flushed with carbon dioxide and the packages were sealed under a vacuum of 50 mm of Hg.

The samples were stored at 4.4°, 22.2°, and 37.8°C for 4 days. After 4 days, the samples stored at 22.2° and 37.8°C were totally unacceptable. Respiration of the fruit at these temperatures caused large amounts of gas to accumulate within the package. The apples stored at 4.4°C were acceptable and very little gas was produced because of the retarded respiration rate at this temperature.

Based upon the results of the preliminary test, a 14-day controlled storage temperature study was conducted with apples. Delicious apples were packaged in Saranex #28 (a co-extrusion of polyethylene-saran-polyethylene) which has a low oxygen and water vapor transmission rate. The packages were flushed with carbon dioxide and vacuum packaged with 50 mm of Hg. These samples were stored along with non-packaged samples at 4.4°, 22.2°, and 27.8°C.

After 48 hours, there was no visible change in any of the apples. The vacuum on the packaged apples stored at 22.2°C was relaxed because of out-gassing. This condition was more pronounced in packages stored at 37.8°C. These packages were fully extended because of outgassing.

The packages stored at 4.4°C were still under vacuum and there was no sign of out-gassing.

After 11 days, the apples stored at 4.4°C were in excellent condition. The vacuum on the packaged apples was still intact. There was no apparent change in the appearance or physical condition of the apples.

After 11 days, the apples stored at 22.2°C were slightly soft and discolored. Discoloration and softening were most noticeable in the packaged samples. All apples stored at 37.8°C for 11 days were quite soft. The packaged apples stored at 37.8°C were extremely discolored and very soft. The temperature test was discontinued after 2 weeks. Out-gassing had caused the vacuum on the packaged apples stored at 4.4°C to relax slightly. These apples, both packaged and non-packaged, were in excellent condition. After 2 weeks, none of the apples stored at 22.2°C or 37.8°C were acceptable. These samples were soft and discolored and these defects were more pronounced in the packaged samples. The non-packaged apples stored at 37.8°C also showed some signs of dehydration.

Two Delicious apples and 2 oranges, packaged and non-packaged, were stored in a chamber containing a 90 to 100 percent oxygen atmosphere. The packaged samples were sealed under a vacuum of 50 mm of Hg. The packaging material used was SLP-4. The temperature of the chamber was 22.2°C.

After 48 hours, there was no visible change in any of the fruit. Out-gassing in the packaged orange had negated the effect of vacuum packing.

The non-packaged orange showed some evidence of shrivelling within 5 days. Within a similar time period, out-gassing had negated the vacuum in the packaged apple. There were no other visible changes in the samples at this stage of the test.

At the 7th day, the packaged orange had brown spots on the skin. The apples showed no visible change.

The chamber was opened and the test samples were removed after 13 days.

The packaged orange was very discolored with brown spots over 50 percent of its surface. The non-packaged orange was dehydratec and shrivelled.

The non-packaged apple showed no change. It was firm and there was no discoloration. The packaged apple also showed very little change. Its color was slightly darker but was firm and free of spots and browning.

The package containing the orange was open at a heat seal and one seal on the apple package was weakened. This was caused by the excessive gas pressure produced by the metabolically active fruit.

The apples were evaluated by a technical panel. The oranges were unacceptable and hence were not tasted. The packaged apple had a highly aromatic flavor. The non-packaged apple had a fresher taste and the "apple" flavor was not as pronounced. This difference in flavor appeared to be a function of packaging. The package retained the volatile constituents creating an atmosphere different from that of the non-packaged apple. This flavor difference should be evaluated further to assess the advisability of packaging apples for flight.

Summary of Results

1. Fresh fruit is not stable under high vacuum conditions.
2. Changing the pressure to 5 psia does not change the shelf-life of fruit when other conditions remain constant.
3. Increased storage temperature decreases the stability of fresh fruit.
4. An oxygen rich atmosphere does not alter the shelf-life of apples within a 2-week period.
5. Oranges, bananas and Rome Beauty apples are not suitable for spacecraft feeding.
6. Delicious apples are compatible with the spacecraft environment and may be stored for at least 7 days under spacecraft conditions.
7. Packaging apples in a high barrier material may adversely affect the acceptability over long periods of storage.

Oranges and bananas are not suitable for spacecraft feeding. Excessive out-gassing and an extremely short shelf-life limit their utilization. Apples are much more stable and test results indicate that Delicious apples could be stored under present spacecraft conditions for at least 7 days. Shelf-life could be extended with lower storage temperatures.

The stability of all fresh fruit appears to be limited when packaged under a hard vacuum. This condition, however, may be related to the functional properties of packaging materials and the respiration rate of fruit.

The packaging materials used had extremely low gas and water vapor transmission rates. The discoloration and softening of packaged apples was probably caused by an excessive amount of carbon dioxide retained in the package. Other investigations indicate that a high level of carbon dioxide may have a detrimental effect on apple quality and appearance.

Before apples are approved for spacecraft feeding, additional tests should be conducted with low barrier packaging materials such as polyethylene or polystyrene. The materials will allow gases to escape and the atmosphere within the package would not become saturated with carbon dioxide.

2.7 Production Guides

Production guides were documented for several food products which were developed during the Apollo Program. Table 48 includes the number and title of each production guide. Production guides are included in Supplement 1 of this report.

2.8 Food Stabilization Study

Apollo food packages were currently treated with 8-quinolinol sulfate after the contents had been consumed to prevent microbial growth and subsequent odor and gas production. Treatment was accomplished by the addition of one gram of 8-quinolinol sulfate in pill-form into the food package immediately after consumption. Food waste from the Mobile Quarantine Facility was also treated with powdered

8-quinolinol sulfate and sealed in double polyethylene bags and stored for the duration of the quarantine period. The moisture in the food residue was utilized to dissolve the 8-quinolinol sulfate.

Physical examination of returned flight food packages revealed very little evidence of putrefaction. However, the odor of 8-quinolinol sulfate can mask many disagreeable odors and mold growth was evident on many of the returned food packages from both the spacecraft and the Mobile Quarantine Facili

An experiment was designed to compare the relative antimicrobial effectiveness of 8-quinolinol sulfate and benzalkonium chloride in food in residual food.

Rehydratable flight food items were utilized to compare the 2 compounds. Banana pudding, chicken salad and cocoa were packaged in flight food packages by a contractor and, therefoı had complied with the microbiological specifications for space food. Orange drink (Tang) and non-fat dry milk were packaged in the laboratory in packages fabricated from polyethylene-mylar-aclar-polyethylene laminate. Aseptic techniques were not followed while packaging the orange drink and the non-fat dry milk. The antimicrobial agents, 8-quinolinol sulfate and quaternary ammonium compounds were added to the dry food prior to rehydration. The 8-quinolinol sulfate was purchased from Baker Chemical Company and the quaternary ammonium compound was supplied by Economics Laboratory, Inc. The quaternary ammonium compound, 50 percent active alkyl dimethyl benzyl ammonium chloride, was prepared for this study. The specially prepared quaternary ammonium compound possessed the following properties: 1) compatible with non-ionic surface active agents, 2) freely soluble in water, and 3) odorless in the powdered form as well as in solution. The antimicrobial agents were added to the dry food through the feeding tube at the following concentrations: 0.1, 0.5, 2, 3 and 4 percent. The concentration was based upon the total weight of rehydrated food. Sterile distilled water was added through the feeding tube to rehydrate the food and antimicrobial agent mixture. Two food packages were prepared at each concentration for each microbial agent. One set was incubated at 35°C, while the other was stored at room temperature. One package of each food which did not contain antimicrobial agent was stored at the same conditions to serve as a control.

The pH of the controls was measured immediately after rehydration. A microbiological analysis of each package was conducted at the following intervals: 0, 5, 15, 30, and 60 days. Eleven gram sample aliquots were withdrawn through the mouthpiece and transferred to 99 ml of buffered distilled water. Total aerobic count, total coliform, and total yeast and mold counts were performed in accordance with the Standard Methods for the Examination of Dairy Products. Analysis for total coliform and yeast and mold were plated at dilutions of 1:1 and 10^{-1}. Total aerobic counts were plated at 4 dilutions. Initial samples were plated at 10^{-1}, 10^{-2}, 10^{-3}, and 10^{-4}. Subsequent samples were plated at higher dilutions based upon the previous count.

This study was completed and data reported in a technical manuscript (see Appendix E).

2.9 Sensory Evaluation of Food Samples

A large number of food samples (900) were evaluated by taste panels. Food samples evaluated included food items from the Apollo Food System, samples submitted by industrial food companies, and products derived from product development.

A technically trained panel usually performed preliminary evaluations on all samples submitted. Members of the technical panel were selected on the basis of triangle testing technics. Subsequent to this evaluation, samples were evaluated by a larger non-technical panel and included male and female participants. Participants recorded preferences on a 9-point hedonic scale.

Another taste panel was composed of the astronauts designated as flight crewmembers. Preferences were recorded on a 9-point hedonic scale.

2.10 New Food Products Introduced into the Apollo Food System

Several new food products were introduced into the Apollo Food System during the contract period. Qualification and spacecraft compatibility tests were performed for many of these products. New products included: freeze-dried scrambled eg beef and gravy (wet pack, meatballs (wet pack), chocolate bar, chocolate and caramel sticks, orange juice crystals, cream of tomato soup, jelly, peanut butter, mustard, catsup, pecans, chicken and rice soup, cranberry orange relish, beef jerky lobster bisque, peach ambrosia, spiced oat cereal, thermostabilize mixed fruit, thermostabilized peaches, vanilla pudding, lemon pudding, romaine soup, crab mushroom soup, cheddar cheese spread, frozen sandwiches, bread, ham sandwich spread, tuna sandwich spread, chicken sandwich spread, hamburger (wet pack), lemonade, tea, turkey and gravy (wet pack), beef and potatoes (wet pack), ham and potatoes (wet pack), frankfurters (wet pack), fruitcake, potassium supplemented beverages, dried apricots, dried peaches, dried pears, instant grits, ham (wet pack), and ham (irradiated).

2.11 Caloric Expenditures for the Apollo Flights

A comparison of the mean daily caloric expenditures of Apollo crews 7 through 12 calculated from carbon dioxide data collected during flight, average daily caloric intake, and total weight losses in-flight is presented in Table 49. Mean calculated daily expenditures ranged from 2050 to 2752 calories as compared with mean daily intakes ranging from 1501 to 1988 calories for the various Apollo missions. The mean expenditure (carbon dioxide data) for the Apollo missions was found to be 2357 calories per day. This is in agreement with earlier simulation studies which predicted the daily caloric need during flight to be from 2000 to 2500.

From a regression coefficient computed from flight data, it was found that at an intake of 2357 calories per day total weight losses would average 4.1 pounds per person. It was also predicted that for zero weight loss an average of 3459 calories per day should be consumed.

It has been speculated that the discrepancy between the figures determined from simulation studies and the values predicted from flight data may be due to an inherent factor in the space environment which leads to a redistribution and loss of body water resulting in weight loss. It is also a possibility that the actual caloric consumption of the astronauts has been over-estimated since food from packages not returned to the Food and Nutrition Laboratory is assumed to have been entirely consumed.

2.12 Freeze-Dried Chicken Muscle

2.12.1 Lipid Experiment

An experiment utilizing freeze-dried chicken muscle was initiated to investigate lipid chemistry of a freeze-dried system. The total lipid content, fatty acid composition of the total lipid fraction, fatty acid composition of the neutral and phospholipid fractions was performed on experimental samples.

Freeze-dried chicken muscle, which had been cooked to an internal temperature of 87.8°C, was packaged and stored at 3 temperatures 4.4°, 22.2°, and 37.8°C). Lipid analyses were performed at the en of 3, 6, and 12 months.

Data from the chicken muscle storage study revealed 2 unknown compounds which persistently appeared in the GLC chromatograms. Identification of these compounds was essential for interpretation of the data. The 2 unknown compounds were isolated from the phospholipid fraction and identified via GLC retention time and infra-red spectra. These compounds have been reported to be present in chicken lipid by other researchers, but have always been referred to as unknown C-15 and C-17. They usually appear in trace amounts, which probably accounts for their unknown identity.

Isolation of the unknown compounds was accomplished by trapping the effluent from the splitter on the GLC column into cold chloroform. The chloroform was dried onto a KBr pellet for the infra-red studies. Twenty to 30 GLC injections were required in order to obtain sufficient unknown for evaluation. The infra-red spectra and the GLC retention time of the C-15 compound was identical to palmitaldehyde dimethyl acetal. Infra-red spectra and retention time from the C-17 compound was identical to stearaldehyde dimethyl acetal. These findings were reported as a research note in *Poultry Science* (see Appendix F.

2.12.2 <u>Amino Acid Experiment</u>

The occurrence of nonenzymatic browning has been observed in freeze-dried foods. The chemical reactions involved in this phenomenon have not been completely elucidated. One hypothesis is that aldehydes or similar compounds react with nitrogen compounds such as amino acids to form the brown pigment. Epsilon amino groups on lysine and similar compounds are particularly labile. When lysine, an essential amino acid, is involved in this reaction it becomes unavailable for human utilization. The nutritional implications are evident. Lysine, with a free epsilon amino group, is also required for effective action of the enzyme trypsin.

Since many of the space foods are freeze-dried and the length of space missions are increasing, nonenzymatic browning becomes an important consideration. The amino acid content of these foods also become critical. An experiment was designed to investigate lysine availability and amino acid content with respect to storage environment and length of storage.

Muscle samples, thigh and breast, were used in the investigation. Control samples were obtained from raw muscle, and cooked muscle (prefreezing, postfreezing and postfreeze-drying). The cooked samples were heated to an internal breast temperature of 87.8°C. Samples were frozen at -9.4°, -100°, and -196°C. Two types of packaging materials, a laminate of polyethylene-aclar-mylar-polyethylene and Saranex (a co-extrusion of polyethylene-saran-polyethylene) were used to package the samples which were stored for 3, 6, and 12 months at 4.4°, 22.2°, and 37.8°C.

At the termination of each storage period, the following analyses were conducted; amino acid analysis, lysine availability, and pigment measurements. Data are being reviewed and a manuscript is in preparation.

2.13 Food Microbiology

A large quantity of Apollo food samples were analyzed by the Microbiology Laboratory during the contract period. All of these samples were assayed in accordance with Addendum 1E, "Microbiological Requirements of Space Food Prototypes," U.S. Army Natick Laboratories.

2.14 Amino Acid Analysis

Several Apollo food items have been analyzed for amino acid composition in conjunction with a storage study conducted by the U.S. Army Natick Laboratories, Natick, Massachusetts. Statistical analyses are being performed on the amino acid data.

2.15 Ingested Peroxide Study

Liver and tissue samples submitted under Contract NAS 9-10826, "Metabolism of Ingested Peroxides" were analyzed chemically. Lipid was quantitatively extracted from liver samples and analyzed for cholesterol content and fatty acid composition. Total hepatic lipids were fractionated into neutral and phospholipids via column chromatography. Fatty acid profiles were subsequently determined for both fractions. Light and dark muscle samples were analyzed for amino acid composition.

2.16 Flexible Packaging Materials

Since flexible packaging materials were used extensively in the Apollo Food System, available materials were investigated to determine applicability. This information was used as evaluation-design criteria for flexible packages in the Apollo Food System. Flexible packaging materials may be categorized in a variety of ways, but from the standpoint of application the most useful classification is one by properties. The most important properties are generally considered to be the following: 1) water vapor and gas barrier, 2) heat sealabilit 3) impact strength, 4) tensile strength, and 5) tear strength.

1. Water vapor and gas barrier films

A film from this category is usually chosen for an application which requires a package with a low transmission rate. Examples of this category are as follows:

a. Polyvinylidene/Polyvinyl Chloride Copolymer (Saran)

This material is one of the best gas barrier materials and also an excellent water vapor barrier. Saran is difficult to seal, however, and it usually requires a heat sealable coating if it is to be formed into a bag or pouch.

b. Fluorohalocarbon Film (Aclar)

Aclar is one of the best water vapor barriers and is a good gas barrier. It is extremely difficult to seal and is usually used only in laminates with other materials.

c. Polyester (Mylar)

Although it is usually used because of its excellent strength characteristics, polyester is also a good gas and water vapor barrier. Polyester must also be coated to effect a good heat seal.

2. Heat Sealability

Many materials are heat sealable. This characteristic is a basic requirement for the formation of bags and pouches. Some of the better sealing materials are as follows:

a. Polyethylene (Low Density)

Low density polyethylene is used where good low temperature heat seals are required. Seals with this material are usually as strong or stronger than the material from which they are formed.

b. Ionomer (Surylan A)

Ionomer films are relatively new in packaging. This material has a wider range of heat seal temperatures and is a slightly better barrier than polyethylene. Ionomer heat seals have excellent strength and consistency.

c. Polyvinyl Chloride

Polyvinyl chloride has a higher sealing range than polyethylene or ionomer and is used where the package is subjected to high use temperatures. As with the first 2 examples, polyvinyl chloride seals have excellent strength characteristics.

3. Impact Strength

Impact strength is important if a package is subjected to rough handling. Some of the films with good impact strength are:

a. Polycarbonate Film

Polycarbonate film has the highest impact strength of any film available. This material is used for high strength thermoformed blister packs and for steam sterilizable packages. As well as having high impact strength, polycarbonate also has a high maximum use temperature and excellent chemical resistance.

b. Polyester (Mylar)

As stated previously, this material combines high barrier properties as well as high strength properties. Its impact strength is not as high as polycarbonate but its other characteristics make it more generally useful as a packaging film.

c. Polyurethane

Polyurethane has generally good strength properties. As well as high impact strength, polyurethane has high tear and tensile strength. This material can be used unsupported. Polyurethane heat seals between 300° and 375°F.

4. Tensile Strength

Tensile strength is a property required in a package which will be subjected to high stress and rough handling. A package which will be subjected to heavy loads requires a material with high tensile strength to prevent rupture of the package.

a. Polyester (Mylar)

Polyester has a very high tensile strength rating. This characteristic coupled with its other properties makes it one of the best films for applications requiring good strength properties.

b. Polypropylene, Biaxially Oriented

Polypropylene has high tensile strength and good water vapor barrier properties. This material is used where strength is required in a low cost material.

c. Nylon

Nylon is usually considered where strength is a factor in the packaging decision. It has good tensile strength, good high and low temperature characteristics, and fairly good barrier properties.

5. Tear Strength

Tear strength is measured in 2 ways. Usually a material's initial tear resistance and the amount of energy required to continue a tear are considered.

a. Polyurethane

Polyurethane has extremely good initial tear resistance. Once the tear is started, however, it requires less force to continue the tear.

b. Polycarbonate

As with impact strength, polycarbonate ranks very high in tear resistance.

c. Polyvinyl Fluoride

Polyvinyl fluoride has very good tear strength as well as a generally high rating in the other strength properties. This material is quite expensive and is not approved by the Food and Drug Administration for food use. These factors limit its use.

The properties considered above are only a few of the factors involved in choosing a packaging film. Some special applications require a material with special properties not listed here.

There is no perfect packaging film. Each material has a disadvantage to its universal use in packaging. The problems incurred with unsupported material are quite often overcome by using a laminate. By combining layers of dissimilar materials, one can build the combination of properties required in a package. The improved technology of laminating films has done much toward providing the optimum material for many difficult packaging problems.

2.17 Kinetics of Lipid Oxidation in Freeze-dried Foods

An investigation was initiated to study the kinetics of lipid oxidation in freeze-dried foods. Several gases - hydrogen, nitrogen, xenon, neon, argon, krypton, helium, ammonia, and oxygen - were used to break the chamber vacuum. Oxidation rates were established for these compounds. This project is still active and will be completed under Contract NAS 9-13291.

2.18 Flight Food Production and Packaging

Several food items were produced and/or packaged for the Apollo missions at the Manned Spacecraft Center, Houston, Texas. Items included bread, frozen sandwiches, pecans, in-suit food bars freeze-dried soups, potassium-fortified beverages, beef jerky, mixed fruit, diced peaches, and puddings.

2.19 Apollo Mission Support

Apollo mission support was provided preflight at KSC and postflight on the recovery ship. For Apollo 16 and 17, personnel assisted in food preparation, residual food collection, and collection of urine and fecal samples during the preflight period.

Postflight support was provided on the recovery ship for Apollo 12, 13, and 16. Support functions were similar to those delineated for preflight.

2.20 Analysis of Apollo Fecal Samples

Apollo fecal samples (preflight, in-flight and postflight) were analyzed for fatty acid, crude fiber, lipid, moisture, mineral (calcium, phosphorus, potassium, sodium, magnesium, chloride) and caloric content. These analyses were performed under Contract NAS 9-11843 "Skylab Food Test and Integration," and results reported in Monthly and Quarterly Reports entitled "Fecal Material Analysis."

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TABLE 1. APOLLO 7 (SCHIRRA, CDR)

DAY 1	DAY 2	DAY 3	DAY 4
MEAL A	MEAL A	MEAL A	MEAL A
Peaches (R) Bacon Squares (8) Cinnamon Toasted Bread Cubes (8) Breakfast Drink (R)	Applesauce (R) Sausage Patties (R) Apricot Cereal Cubes (8) Breakfast Drink (R)	Fruit Cocktail (R) Bacon Squares (8) Cinnamon Toasted Bread Cubes (8) Cocoa (R) Breakfast Drink (R)	Canadian Bacon and Applesauce (R) Strawberry Cereal Cubes (8) Cinnamon Toasted Bread Cubes (8) Breakfast Drink (R)
(Calories 500)	(Calories 595)	(Calories 669)	(Calories 611)
MEAL B	MEAL B	MEAL B	MEAL B
Corn Chowder (R) Chicken Sandwiches (6) Beef Stew Bites (8) Sugar Cookies (8) Orange Drink (R) Breakfast Drink (R)	Tuna Salad (R) Cinnamon Toasted Bread Cubes (8) Chocolate Pudding (R) Breakfast Drink (R)	Beef Pot Roast (R) Sugar Cookies (8) Butterscotch Pudding(R) Breakfast Drink (R)	Pea Soup (R) Salmon Salad (R) Cheese Sandwiches (6) Grapefruit Drink (R) Breakfast Drink (R)
(Calories 809)	(Calories 895)	(Calories 665)	(Calories 756)
MEAL C	MEAL C	MEAL C	MEAL C
Beef and Gravy (R) Brownies (8) Chocolate Pudding (R) Grapefruit Drink (R)	Spaghetti w/Meat Sauce (R) Beef Bites (8) Banana Pudding (R) Pineapple Fruitcake (6) Pineapple-Grapefruit Drink (R)	Potato Soup (R) Chicken Salad (R) Barbecue Beef Bites (8) Gingerbread (8) Grapefruit Drink (R)	Shrimp Cocktail (R) Chicken and Gravy (R) Cinnamon Toasted Bread Cubes (8) Date Fruitcake (6) Pineapple-Grapefruit Drink (R)
(Calories 917)	(Calories 915)	(Calories 975)	(Calories 965)
Total Calories 2226	Total Calories 2408	Total Calories 2309	Total Calories 2332

TABLE 2. APOLLO 7 (CUNNINGHAM, LMP)

	DAY 1	DAY 2	DAY 3	DAY 4
MEAL A	Peaches (R) Bacon Squares (8) Cinnamon Toasted Bread Cubes (8) Grapefruit Drink (R) (Calories 696)	Applesauce (R) Beef Hash (R) Cinnamon Toast (8) Apricot Cereal Cubes (8) Grapefruit Drink (R) (Calories 786)	Fruit Cocktail (R) Bacon Squares (8) Cinnamon Toast (8) Orange Drink (R) (Calories 500)	Canadian Bacon and Applesauce (R) Cinnamon Toast (8) Apricot Cereal Cubes (8) Pineapple-Grapefruit Drink (R) (Calories 611)
MEAL B	Cream of Chicken Soup (R) Chicken Sandwiches (6) Beef Sandwiches (8) Sugar Cookies (8) Chocolate Pudding (R) Pineapple-Grapefruit Drink (R) (Calories 1020)	Tuna Salad (R) Beef Sandwiches (8) Cinnamon Toast (8) Butterscotch Pudding (R) Pineapple-Grapefruit Drink (R) (Calories 846)	Corn Chowder (R) Barbecued Beef Bites (8) Cinnamon Toasted Bread Cubes (8) Chocolate Pudding (R) Orange-Grapefruit Drink (R) (Calories 1060)	Salmon Salad Beef Sandwiches (8) Cinnamon Toasted Bread Cubes (8 Gingerbread (8) Cocoa (R) (Calories 1017)
MEAL C	Beef and Gravy (R) Beef Stew Bites (8) Cinnamon Toast (8) Brownies (8) Orange-Grapefruit Drink (R) (Calories 788)	Beef and Vegetables (R) Barbecued Beef Bites (8) Cinnamon Toasted Bread Cubes (8) Banana Pudding (R) Orange Drink (R) (Calories 897)	Chicken Salad (R) Beef Sandwiches (8) Cinnamon Toast (8) Pineapple Fruitcake (6) Orange-Grapefruit Drink (R) (Calories 912)	Creamed Chicken Bites (8) Chicken and Gravy (R) Toasted Bread Cubes (8) Date Fruitcake (6) Orange Drink (R) (Calories 897)
	Total Calories 2504	Total Calories 2529	Total Calories 2472	Total Calories 2465

TABLE 3. APOLLO 7 (EISELE, CMP)

	DAY 1	DAY 2	DAY 3	DAY 4
MEAL A	Peaches (R) Corn Flakes (R) Bacon Squares (8) Toasted Bread Cubes (8) Grapefruit Drink (R) Breakfast Drink (R) (Calories 813)	Applesauce (R) Bacon Squares (8) Cinnamon Toasted Bread Cubes (8) Orange Drink (R) Breakfast Drink (R) (Calories 700)	Fruit Cocktail (R) Sausage Patties (R) Apricot Cereal Cubes (8) Cocoa (R) Breakfast Drink (R) (Calories 710)	Canadian Bacon and Applesauce (R) Apricot Cereal Cubes (8) Sugar Frosted Flakes (R) Pineapple-Grapefruit Drink (R) Breakfast Drink (R) (Calories 660)
MEAL B	Cream of Chicken Soup (R) Chicken and Vegetables (R) Sugar Cookies (8) Chocolate Pudding (R) Orange-Grapefruit Drink (R) (Calories 913)	Salmon Salad (R) Butterscotch Pudding(R) Vanilla Ice Cream (8) Grapefruit Drink (R) (Calories 963)	Canadian Bacon and Applesauce (R) Beef Pot Roast (R) Sugar Cookies (8) Butterscotch Pudding (R) Cocoa (R) (Calories 967)	Pea Soup (R) Salmon Salad (R) Turkey Bites (8) Cheese Sandwiches (6) Grapefruit Drink (R) (Calories 852)
MEAL C	Chicken Salad (R) Beef and Gravy (R) Date Fruitcake (4) Cocoa (R) (Calories 788)	Beef Hash (R) Chicken and Gravy (R) Cinnamon Toasted Bread Cubes (8) Pineapple Fruitcake (4) Grapefruit Drink (R) (Calories 892)	Potato Soup (R) Beef and Gravy (R) Creamed Chicken Bites (8) Cinnamon Toasted Bread Cubes (8) Pineapple-Grapefruit Drink (R) (Calories 832)	Sausage Patties (R) Cinnamon Toasted Bread Cubes (8) Date Fruitcake (6) Grapefruit Drink (R) (Calories 991)
	Total Calories 2514	Total Calories 2555	Total Calories 2509	Total Calories 2503

TABLE 4. APOLLO 8 (BORMAN, CDR; ANDERS, LMP; AND LOVELL, CMP)

MEAL	DAY 1*, 5, 9	DAY 2, 6, 10	DAY 3, 7, 11	DAY 4, 8, 12*
A	Peaches Bacon Squares (8) Cinnamon Toasted Bread Cubes (8) Grapefruit Drink	Canadian Bacon and Applesauce Sugar Coated Corn Flakes Apricot Cereal Cubes (8) Grapefruit Drink Orange Drink	Fruit Cocktail Bacon Squares (8) Cinnamon Toasted Bread Cubes (8) Cocoa Orange Drink	Canadian Bacon and Applesauce Toasted Bread Cubes (8) Strawberry Cereal Cubes (6) Cocoa Orange Drink
B	Corn Chowder Chicken and Gravy Toasted Bread Cubes (6) Sugar Cookie Cubes (6) Cocoa Orange Drink	Tuna Salad Chicken and Vegetables Cinnamon Toasted Bread Cubes (8) Pineapple Fruitcake (4) Pineapple-Grapefruit Drink	Cream of Chicken Soup Beef Pot Roast Toasted Bread Cubes (8) Butterscotch Pudding Grapefruit Drink	Pea Soup Chicken and Gravy Cheese Sandwiches (6) Bacon Squares (6) Grapefruit Drink
C	Beef and Gravy Beef Sandwiches (4) Cheese-Cracker Cubes (8) Chocolate Pudding Orange-Grapefruit Drink	Spaghetti and Meat Sauce Beef Bites (6) Bacon Squares (6) Banana Pudding Grapefruit Drink	Potato Soup Chicken Salad Turkey Bites (6) Graham Cracker Cubes (6) Orange Drink	Shrimp Cocktail Beef and Vegetables Cinnamon Toasted Bread Cubes (8) Date Fruitcake (4) Orange-Grapefruit Drink

* Day 1 consists of Meals B and C only; Day 12 consists of Meal A only. Each crewmember will be provided with a total of 33 meals.

TABLE 5. APOLLO 9 (MC DIVITT, CDR)

MEAL	DAY 1*, 5, 9	DAY 2, 6, 10	DAY 3, 7, 11	DAY 4, 8
A	Peaches Bacon Squares (8) Cinnamon Toasted Bread Cubes (8) Grapefruit Drink Orange Drink	Canadian Bacon and Applesauce Sugar Coated Corn Flakes Brownies (8) Grapefruit Drink Grape Drink	Fruit Cocktail Bacon Squares (8) Cinnamon Toasted Bread Cubes (8) Cocoa Orange Drink	Sausage Patties Peaches Bacon Squares (8) Cocoa Grape Drink
B	Salmon Salad Chicken and Gravy Toasted Bread Cubes (6) Sugar Cookie Cubes (6) Cocoa	Tuna Salad Chicken and Vegetables Cinnamon Toasted Bread Cubes (8) Pineapple Fruit Cake (4) Pineapple-Grapefruit Drink	Cream of Chicken Soup Beef Pot Roast Toasted Bread Cubes (8) Butterscotch Pudding Grapefruit Drink	Pea Soup Chicken and Gravy Cheese Sandwiches (6) Bacon Squares (6) Grapefruit Drink
C	Beef and Gravy Beef Sandwiches (4) Cheese-Cracker Cubes (8) Chocolate Pudding Orange-Grapefruit Drink	Spaghetti and Meat Sauce Beef Bites (6) Bacon Squares (6) Banana Pudding Grapefruit Drink	Beef Hash Chicken Salad Turkey Bites (6) Graham Cracker Cubes (6) Orange Drink	Shrimp Cocktail Beef and Vegetables Cinnamon Toasted Bread Cubes (8) Date Fruitcake (4) Orange-Grapefruit Drink

* Day 1 consists of Meals B and C only.
Each crewmember will be provided with a total of 32 meals.

TABLE 6. APOLLO 9 (SCHWEICKART, LMP)

MEAL	DAY 1*, 5, 9	DAY 2, 6, 10	DAY 3, 7, 11	DAY 4, 8
A	Peaches Bacon Squares (8) Cinnamon Toasted Bread Cubes (8) Grapefruit Drink Orange Drink	Canadian Bacon and Applesauce Sugar Coated Corn Flakes Brownies (8) Grapefruit Drink Grape Drink	Fruit Cocktail Bacon Squares (8) Cinnamon Toasted Bread Cubes (8) Cocoa Orange Drink	Sausage Patties Peaches Bacon Squares (8) Cocoa Grape Drink
B	Salmon Salad Chicken and Gravy Toasted Bread Cubes (6) Sugar Cookie Cubes (6) Cocoa	Tuna Salad Chicken and Vegetables Cinnamon Toasted Bread Cubes (8) Pineapple Fruitcake (4) Pineapple-Grapefruit Drink	Cream of Chicken Soup Beef Pot Roast Toasted Bread Cubes (8) Butterscotch Pudding Grapefruit Drink	Pea Soup Chicken and Gravy Cheese Sandwiches (6) Bacon Squares (6) Grapefruit Drink
C	Beef and Gravy Beef Sandwiches (4) Cheese-Cracker Cubes (8) Chocolate Pudding Orange-Grapefruit Drink	Spaghetti and Meat Sauce Beef Bites (6) Bacon Squares (6) Banana Pudding Grapefruit Drink	Beef Hash Chicken Salad Turkey Bites (6) Graham Cracker Cubes (6) Orange Drink	Spaghetti and Meat Sauce Beef and Vegetables Cinnamon Toasted Bread Cubes (8) Date Fruitcake (4) Orange-Grapefruit Drink

* Day 1 consists of Meals B and C only.
Each crewmember will be provided with a total of 32 meals.

TABLE 7. APOLLO 9 (SCOTT, CMP)

MEAL	DAY 1*, 5, 9	DAY 2, 6, 10	DAY 3, 7, 11	DAY 4, 8
A	Peaches Bacon Squares (8) Cinnamon Toasted Bread Cubes (8) Grapefruit Drink Orange Drink	Canadian Bacon and Applesauce Sugar Coated Corn Flakes Brownies (8) Grapefruit Drink Grape Drink	Fruit Cocktail Bacon Squares (8) Cinnamon Toasted Bread Cubes (8) Cocoa Orange Drink	Sausage Patties Peaches Bacon Squares (8) Cocoa Grape Drink
B	Salmon Salad Chicken and Gravy Toasted Bread Cubes (6) Sugar Cookie Cubes (6) Cocoa	Tuna Salad Chicken and Vegetables Cinnamon Toasted Bread Cubes (8) Pineapple Fruitcake (4) Pineapple-Grapefruit Drink	Cream of Chicken Soup Beef Pot Roast Toasted Bread Cubes (8) Butterscotch Pudding Grapefruit Drink	Pea Soup Chicken and Gravy Cheese Sandwiches (6) Bacon Squares (6) Grapefruit Drink
C	Beef and Gravy Beef Sandwiches (4) Cheese-Cracker Cubes (8) Chocolate Pudding Orange-Grapefruit Drink	Spaghetti and Meat Sauce Beef Bites (6) Bacon Squares (6) Banana Pudding Grapefruit Drink	Beef Hash Chicken Salad Turkey Bites (6) Graham Cracker Cubes (6) Orange Drink	Shrimp Cocktail Beef and Vegetables Cinnamon Toasted Bread Cubes (8) Date Fruitcake (4) Orange-Grapefruit Drink

* Day 1 consists of Meals B and C only.
Each crewmember will be provided with a total of 32 meals.

TABLE 8. APOLLO 9 LM MENU

DAY 1

MEAL A

Chicken and Gravy
Butterscotch Pudding
Sugar Cookie Cubes (6)
Orange-Pineapple Drink
Grape Drink

MEAL B

Chicken Salad
Beef Sandwiches (6)
Date Fruitcake (4)
Chocolate Pudding
Orange Drink

MEAL C

Beef Hash
Bacon Squares (8)
Strawberry Cereal Cubes (6)
Pineapple-Grapefruit Drink
Grape Drink

2 man-days are required
2 meals per overwrap

TABLE 9. APOLLO 10 (STAFFORD, CDR)

MEAL	DAY 1*, 5, 9	DAY 2, 6, 10	DAY 3, 7, 11	DAY 4, 8
A	Peaches Bacon Squares Cinnamon Toasted Bread Cubes (4) Grapefruit Drink Orange Drink	Fruit Cocktail Sugar Coated Corn Flakes Bacon Squares (8) Grapefruit Drink Grape Drink	Peaches Bacon Squares (8) Strawberry Cubes (4) Cocoa Orange Drink	Fruit Cocktail Sausage Patties Bacon Squares (8) Cocoa Grape Drink
B	Salmon Salad Chicken and Rice** Sugar Cookie Cubes (4) Cocoa Grape Punch	Potato Soup Chicken and Vegetables Tuna Salad Pineapple Fruitcake (4) Orange Drink	Cream of Chicken Soup (Turkey and Gravy-Wet Pack) Butterscotch Pudding Brownies (4) Grapefruit Drink	Potato Soup Pork and Scalloped Potatoes** Applesauce Orange Drink
C	(Beef and Potatoes-Wet Pack) Cheese Cracker Cubes (4) Chocolate Pudding Orange-Grapefruit Drink	Spaghetti and Meat Sauce** (Ham and Potatoes-Wet Pack) Banana Pudding Pineapple-Grapefruit Drink	Pea Soup Beef Stew** Chicken Salad Chocolate Cubes (4) Grape Punch	Shrimp Cocktail Chicken Stew** Turkey Bites (4) Date Fruitcake (4) Orange-Grapefruit Drink

* Day 1 consists of Meal C only.
** New Spoon-Bowl package.

TABLE 10. APOLLO 10 (YOUNG, CMP)

MEAL	DAY 1*, 5, 9	DAY 2, 6, 10	DAY 3, 7, 11	DAY 4, 8
A	Peaches Bacon Squares (8) Cinnamon Toasted Bread Cubes (4) Grapefruit Drink Orange Drink	Fruit Cocktail Sugar Coated Corn Flakes Brownies (4) Grapefruit Drink Grape Drink	Peaches Bacon Squares (8) Strawberry Cubes (4) Cocoa Orange Drink	Fruit Cocktail Sausage Patties Bacon Squares (8) Cocoa Grape Drink
B	Salmon Salad Chicken and Rice** Sugar Cookie Cubes (4) Cocoa Grape Punch	Potato Soup Tuna Salad Chicken and Vegetables Pineapple Fruitcake (4) Pineapple-Grapefruit Drink	Cream of Chicken Soup (Turkey and Gravy-Wet Pack) Butterscotch Pudding Grapefruit Drink	Pea Soup Pork and Scalloped Potatoes* Applesauce Orange Drink
C	(Beef and Potatoes-Wet Pack) Cheese Cracker Cubes (4) Chocolate Pudding Orange-Grapefruit Drink	Spaghetti and Meat Sauce** (Ham and Potatoes-Wet Pack) Banana Pudding Orange Drink	Beef Stew** Chicken Salad Corn Chowder Chocolate Cubes (4) Grape Punch	Shrimp Cocktail Chicken Stew** Turkey Bites (4) Date Fruitcake (4) Orange-Grapefruit Drink

* Day 1 consists of Meal C only.
** New Spoon-Bowl package.

TABLE 11. APOLLO 10 (CERNAN, LMP)

MEAL	DAY 1*, 5, 9	DAY 2, 6, 10	DAY 3, 7, 11	DAY 4, 8
A	Peaches Bacon Squares (8) Cinnamon Toasted Bread Cubes (4) Orange Drink Orange-Pineapple Drink	Fruit Cocktail Sugar Coated Corn Flakes Bacon Squares (8) Orange Drink Grape Drink	Peaches Bacon Squares (8) Strawberry Cubes (4) Cocoa Orange Drink	Fruit Cocktail Sausage Patties Bacon Squares (8) Cocoa Grape Drink
B	Salmon Salad Chicken and Rice** Sugar Cookie Cubes (4) Cocoa Grape Punch	Potato Soup Tuna Salad Chicken and Vegetables Brownies (4) Orange-Grapefruit Drink	Cream of Chicken Soup (Turkey and Gravy-Wet Pack) Cinnamon Toasted Bread Cubes (4) Butterscotch Pudding Pineapple-Grapefruit Drink	Potato Soup Pork and Scalloped Potatoes** Applesauce Orange Drink
C	Cream of Chicken Soup (Beef and Potatoes-Wet Pack) Cheese Cracker Cubes (4) Fruit Cocktail Orange-Grapefruit Drink	Spaghetti and Meat Sauce** (Ham and Potatoes-Wet Pack) Banana Pudding Orange Drink	Pea Soup Chicken Salad Beef Stew** Grape Punch	Shrimp Cocktail Chicken Stew** Turkey Bites (6) Chocolate Cubes (6) Orange-Grapefruit Drink

* Day 1 consists of Meal C only.
** New Spoon-Bowl package.

TABLE 12. APOLLO 10 LM MENU

DAY 1

MEAL A

Fruit Cocktail
Bacon Squares (8)
Brownies (4)
Orange Drink
Grape Punch

MEAL B

Beef and Vegetables
Pineapple Fruitcake (4)
Orange-Grapefruit Drink
Grape Punch

MEAL C

Cream of Chicken Soup
Beef Hash
Strawberry Cubes (4)
Pineapple-Grapefruit Drink

2 man-days only
2 meals per overwrap

TABLE 13. APOLLO 10 PANTRY ITEMS

1. Wet Pack Foods
   - a. Ham and Potatoes
   - b. Beef and Potatoes
   - c. Turkey and Gravy
2. Dried Fruits
   - a. Peaches
   - b. Apricots
3. Extra Beverages (24)
4. Tubed Sandwich Spread
   - a. Ham Salad - 1 tube (4.5 ounce)
   - b. Chicken Salad - 1 tube (4.5 ounce)
5. Bread - 12 slices

TABLE 14

APOLLO 11 (ARMSTRONG - CDR)

MEAL	Day 1*, 5, 9	Day 2, 6, 10	Day 3, 7, 11	Day 4, 8
A	Peaches Bacon Squares (8) Strawberry Cubes (4) Grape Drink Orange Drink	Fruit Cocktail Sausage Patties Cinn. Tstd. Bread Cubes (4) Cocoa Fortified Grapefruit Drink	Peaches Bacon Squares (8) Apricot Cereal Cubes (4) Grape Drink Orange Drink	Canadian Bacon and Applesauce Sugar Coated Corn Flakes Peanut Cubes (4) Cocoa Orange-Grapefruit Drink
B	Salmon Salad Chicken and Rice ** Sugar Cookie Cubes (6) Cocoa Pineapple-Grapefruit Drink	Spaghetti with Meat Sauce Beef Pot Roast Pineapple Fruitcake (4) Orange Drink	Tuna Salad Chicken Stew ** Butterscotch Pudding Cocoa Grapefruit Drink	Ham and Potatoes *** Beef and Gravy Coconut Cubes (4) Banana Pudding Grape Punch
C	Beef and Potatoes *** Cheese Sandwiches (6) Butterscotch Pudding Brownies (4) Grape Punch	Pork and Scalloped Potatoes ** Applesauce Chocolate Pudding Sugar Cookie Cubes (6) Orange-Grapefruit Drink	Cream of Chicken Soup Turkey and Gravy *** Cheese Cracker Cubes (6) Chocolate Cubes (5) Pineapple-Grapefruit Drink	Shrimp Cocktail Beef Stew ** Fruit Cocktail Date Fruitcake (4) Grapefruit Drink
CALORIES/DAY	2331	2289	2350	2248

* Day 1 Consists of Meals B and C Only
** Spoon-Bowl Package
*** Wet-Pack Food

TABLE 15

APOLLO 11 (ALDRIN - LMP)

MEAL	Day 1*, 5, 9	Day 2, 6, 10	Day 3, 7, 11	Day 4, 8
A	Peaches Bacon Squares (8) Strawberry Cubes (4) Grape Drink Grapefruit Drink	Fruit Cocktail Sausage Patties Cinn. Tstd. Bread Cubes (4) Cocoa Orange Drink	Peaches Bacon Squares (8) Apricot Cereal Cubes (4) Grape Drink Grapefruit Drink	Canadian Bacon and Applesauce Sugar Coated Corn Flakes Peanut Cubes (4) Cocoa Orange-Grapefruit Drink
B	Salmon Salad Chicken and Rice ** Sugar Cookie Cubes (4) Cocoa Orange-Grapefruit Drink	Chicken Salad Chicken and Gravy Beef Sandwiches (6) Pineapple Fruitcake (4) Grapefruit Drink	Tuna Salad Chicken Stew ** Banana Pudding Cocoa Pineapple-Grapefruit Drink	Ham and Potatoes *** Cheese Cracker Cubes (6) Coconut Cubes (4) Butterscotch Pudding Grapefruit Drink
C	Beef and Potatoes *** Cheese Sandwiches (6) Banana Pudding Chocolate Cubes (4) Pineapple-Grapefruit Drink	Pork and Scalloped Potatoes ** Applesauce Chocolate Pudding Peanut Cubes (4) Orange-Grapefruit Drink	Cream of Chicken Soup Turkey and Gravy *** Cinn. Tstd. Bread Cubes (4) Brownies (6) Grape Punch	Shrimp Cocktail Beef Stew ** Fruit Cocktail Date Fruitcake (4) Orange Drink
CALORIES/DAY	2285	2341	2297	2292

* Day 1 Consists of Meal B and C Only
** Spoon-Bowl Package
*** Wet-Pack Food

TABLE 16

APOLLO 11 (COLLINS - CMP)

MEAL	Day 1*, 5, 9	Day 2, 6, 10	Day 3, 7, 11	Day 4, 8
A	Peaches Bacon Squares (8) Strawberry Cubes (4) Grape Drink Orange Drink	Fruit Cocktail Sausage Patties Cinn. Tstd. Bread Cubes (4) Cocoa Fortified Grapefruit Drink	Peaches Bacon Squares (8) Apricot Cereal Cubes (4) Grape Drink Orange Drink	Canadian Bacon and Applesauce Sugar Coated Corn Flakes Peanut Cubes (4) Cocoa Orange-Grapefruit Drink
B	Salmon Salad Chicken and Rice ** Sugar Cookie Cubes (6) Cocoa Pineapple-Grapefruit Drink	Potato Soup Beef Pot Roast Pineapple Fruitcake (4) Orange Drink	Tuna Salad Chicken Stew ** Butterscotch Pudding Cocoa Grapefruit Drink	Ham and Potatoes *** Beef and Gravy Coconut Cubes (4) Banana Pudding Grape Punch
C	Beef and Potatoes *** Cheese Sandwiches (6) Butterscotch Pudding Brownies (4) Grape Punch	Pork and Scalloped Potatoes ** Applesauce Chocolate Pudding Sugar Cookie Cubes (6) Orange-Grapefruit Drink	Cream of Chicken Soup Turkey and Gravy *** Chocolate Cubes (6) Pineapple-Grapefruit Drink	Shrimp Cocktail Beef Stew ** Fruit Cocktail Date Fruitcake (4) Grapefruit Drink
CALORIES/DAY	2331	2288	2248	2248

* Day 1 Consists of Meal B and C Only
** Spoon-Bowl Package
*** Wet-Pack Food

TABLE 17

APOLLO 11 LM MENUS

MEAL A.	Bacon Squares (8)
	Peaches
	Sugar Cookie Cubes (6)
	Coffee
	Pineapple-Grapefruit Drink
MEAL B.	Beef Stew
	Cream of Chicken Soup
	Date Fruit Cake (4)
	Grape Punch
	Orange Drink

	UNITS
Extra Beverage	8
Dried Fruit	4
Candy Bar	4
Bread	2
Ham Salad Spread (tube food)	1
Turkey and Gravy	2
Spoons	3
Germicidal Tablets (20)	3

TABLE 18

APOLLO 11 FLIGHT MENU, PANTRY STOWAGE ITEMS

BREAKFAST	UNITS
Peaches	6
Fruit Cocktail	6
Canadian Bacon & Applesauce	3
Bacon Squares (8)	12
Sausage Patties**	3
Sugar Coated Corn Flakes	6
Strawberry Cubes (4)	3
Cinn. Tstd. Bread Cubes (4)	6
Apricot Cereal Cubes (4)	3
Peanut Cubes (4)	3
	51

BEVERAGES	UNITS
Orange Drink	6
Orange-Greapfruit Drink	3
Pineapple-Grapefruit Drink	3
Grapefruit Drink	3
Grape Drink	6
Grape Punch	3
Cocoa	6
Coffee (B)	15
Coffee (S)	15
Coffee (C and S)	15
	75

SALADS/MEATS	UNITS
Salmon Salad	3
Tuna Salad	3
Cream of Chicken Soup	6
Shrimp Cocktail	6
Spaghetti & Meat Sauce*	6
Beef Pot Roast	3
Beef & Vegetables	3
Chicken & Rice*	6
Chicken Stew*	3
Beef Stew*	3
Pork & Scalloped Potatoes*	6
Ham & Potatoes (Wet)	3
Turkey & Gravy (Wet)	6
	57

REHYDRATABLE DESSERTS	UNITS
Banana Pudding	6
Butterscotch Pudding	6
Applesauce	6
Chocolate Pudding	6
	24

DRIED FRUITS	UNITS
Apricots	6
Peaches	6
Pears	6
	24

SANDWICH SPREAD	UNITS
Ham Salad (8 oz.)	1
Tuna Salad (8 oz.)	1
Chicken Salad (8 oz.)	1
Cheddar Cheese (2 oz.)	3
	6

BITES	UNITS
Cheese Cracker Cubes (6)	6
BBQ Beef Bites (4)	6
Chocolate Cubes (4)	6
Brownies (4)	6
Date Fruitcake (4)	6
Pineapple Fruitcake (4)	6
Jellied Fruit Candy (4)	6
Caramel Candy (4)	6

ACCESSORIES	UNITS
Chewing Gum	15
Wet skin cleaning towels	30
Oral Hygiene Kit	1
3 toothbrushes	
1 edible toothpaste	
1 dental floss	
Contingency Feeding System	1
3 food restrainer pouches	
3 beverage packages	
1 valve adapter (pontube)	
Spoons	3
Germicidal Tablets (20)	3

BREAD	UNITS
Rye	6
White	6
	12

TABLE 18 CONTINUED

ACCESSORIES	Unit
Chewing gum	15
Wet skin cleaning towels	30
Oral Hygiene Kit	1
3 toothbrushes	
1 edible toothpaste	
1 dental floss	
Contingency Feeding System	1
3 food restrainer pouches	
3 beverage packages	
1 valve adapter (pontube)	
Spoons	3
Germicidal Tablets (20)	3

TABLE 19

APOLLO 12 (CONRAD - CDR)

MEAL	Day 1*, 5**, 9		Day 2, 6, 10		Day 3, 7, 11		Day 4, 8	
A	Peaches	IMB	Apricots	IMB	Pears	IMB	Canadian Bacon	
	Corn Flakes	R	Sausage Patties	R	Corn Flakes	R	& Applesauce	RSB
	Bacon Squares (8)	IMB	Scrambled Eggs	RSB	Bacon Squares (8)	IMB	Scrambled Eggs	RSB
	Orange Drink	R	Grapefruit Drink	R	Grape Drink	R	Cinnamon Bread (4)	DB
	Coffee w/Sugar	R	Coffee w/Sugar	R	Coffee w/Sugar	R	Orange-G.F. Drink	R
							Coffee w/Sugar	R
B	Tuna Salad	RSB	Turkey & Gravy	WP	Frankfurters	WP	Shrimp Cocktail	R
	Beef & Gravy	WP	Cheese Crackers (4)	DB	Applesauce	RSB	Ham & Potatoes	WP
	Jellied Candy	IMB	Chocolate Pudding	RSB	Chocolate Bar	IMB	Apricots	IMB
	Grape Punch	R	Orange-G.F. Drink	R	P.A.-G.F. Drink	R	Chocolate Pudding	RSB
							Orange Drink	R
C	Cream of Chicken Soup	RSB	Pork & Scalloped Potatoes	RSB	Salmon Salad	RSB	Spaghetti w/Meat	R
	Chicken & Rice	RSB	Bread Slice		Chicken Stew	RSB	Beef Stew	RSB
	Sugar Cookies (4)	DB	Sandwich Spread	WP	Butterscotch Pudding	RSB	Banana Pudding	RSB
	Butterscotch Pudding	RSB	Jellied Candy	IMB	Peaches	IMB	Cocoa	R
	P.A.-G.F. Drink	R	Cocoa	R	Grapefruit Drink	R	Grape Punch	R
			Orange Drink	R				
DAYS TOTAL CALORIES	2215		2346		2328		2106	

* Day 1 consists of Meal B and C only

IMB = Intermediate Moisture Bite

R = Rehydratable

RSB = Rehydratable Spoon-Bowl

WP = Wet Pack

TABLE 20

APOLLO 12 (BEAN - LMP)

MEAL	Day 1*, 5**, 9		Day 2, 6, 10		Day 3, 7, 11		Day 4, 8	
A	Peaches	R	Fruit Cocktail	R	Peaches	R	Fruit Cocktail	R
	Corn Flakes	R	Corn Flakes	R	Corn Flakes	R	Corn Flakes	R
	Canadian Bacon & Applesauce	RSB	Jellied Candy	IMB	Canadian Bacon & Applesauce	RSB	Jellied Candy	IMB
	Cocoa	R	Grapefruit Drink	R	Cocoa	R	Cocoa	R
	Orange Drink	R	P.A.-G.F. Drink	R	Orange Drink	R	Orange-G.F. Drink	R
B	Beef & Gravy	WP	Cream of Chicken Soup	RSB	Potato Soup	RSB	Cream of Chicken Soup	RSB
	Fruit Cocktail	R	Turkey & Gravy	WP	Beef and Gravy	WP	Chicken Stew	RSB
	Jellied Candy	IMB	Peaches	R	Jellied Candy	IMB	Peaches	R
	Grapefruit Drink	R	Orange-G.F. Drink	R	P.A.-G.F. Drink	R	Chocolate Pudding	RSB
							Orange Drink	R
C	Potato Soup	RSB	Pork & Scalloped Potatoes	RSB	Chicken & Rice	RSB	Spaghetti w/Meat	R
	Chicken & Rice	RSB	Bread Slice Sandwich Spread	WP	Fruit Cocktail	R	Banana Pudding	RSB
	Spaghetti w/Meat	R	Chocolate Pudding	RSB	Cinnamon Bread (4)	DB	Cocoa	R
	Butterscotch Pudding	RSB	Cocoa	R	Butterscotch Pudding	RSB	P.A.-G.F. Drink	R
	Orange-G.F. Drink	R	Orange Drink	R	Grapefruit Drink	R		
	DAYS TOTAL CALORIES 2161		2383		2211		2271	

* Day 1 consists of Meal B and C only

IMB = Intermediate Moisture Bite

R = Rehydratable

RSB = Rehydratable Spoon-Bowl

WP = Wet Pack

DB = Dry Bite

** Day 5 consists of Meal A only

TABLE 21

APOLLO 12 (GORDON - CMP)

MEAL	Day 1*, 5, 9		Day 2, 6, 10		Day 3, 7, 11		Day 4, 8	
A	Peaches	IMB	Apricots	IMB	Pears	IMB	Canadian Bacon & Applesauce	RSB
	Corn Flakes	R	Scrambled Eggs	RSB	Corn Flakes	R	Strawberry Cubes (4)	DB
	Bacon Squares (8)	IMB	Sausage Patties	R	Bacon Squares (8)	IMB	Scrambled Eggs	RSB
	Orange Drink	R	Grapefruit Drink	R	Grape Drink	R	Orange-G.F. Drink	R
	Coffee (black)	R	Coffee (black)	R	Coffee (black)	R	Coffee (black)	R
B	Tuna Salad	RSB	Turkey & Gravy	WP	Frankfurters	WP	Shrimp Cocktail	R
	Beef & Gravy	WP	Cheese Crackers (4)	DB	Applesauce	RSB	Ham & Potatoes	WP
	Jellied Candy	IMB	Chocolate Pudding	RSB	Chocolate Bar	IMB	Apricots	IMB
	Grape Punch	R	Orange-G.F. Drink	R	P.A.-G.F. Drink	R	Chocolate Pudding	RSB
							Orange Drink	R
	(Day 5)							
	Beef & Potatoes	WP						
C	Pea Soup	RSB	Pork & Scalloped Potatoes	RSB	Salmon Salad	RSB	Spaghetti w/Meat	R
	Chicken & Rice	RSB	Bread Slice Sandwich Spread	WP	Beef & Gravy	RSB	Beef Stew	RSB
	Sugar Cookies (4)	DB	Date Fruitcake (4)	DB	Butterscotch Pudding	RSB	Banana Pudding	RSB
	Butterscotch Pudding	RSB	Cocoa	R	Peaches	IMB	Cocoa	R
	P.A.-G.F. Drink	R	Orange Drink	R	Grapefruit Drink	R	Grape Punch	R
			Cocoa	R				
	DAYS TOTAL CALORIES	2262		2245		2395		2064

* Day 1 consists of Meal B and C only

IMB = Intermediate Moisture Bite

R = Rehydratable

RSB = Rehydratable Spoon-Bowl

WP = Wet Pack

DB = Dry Bite

TABLE 22

APOLLO 12 LM MENUS

CDR - Red Velcro

Day 1 Meal C

Cream of Chicken Soup	RSB
Ham Salad - Bread	WP
Jellied Candy	IMB
Apricots	IMB
Grapefruit Drink	R
Pineapple-Grapefruit Drink	R

Day 2 Meal A

Peaches	IMB
Scrambled Eggs	RSB
Bacon Squares (8)	IMB
Cocoa	R
Orange Drink	R

Day 2 Meal B

Beef and Gravy	WP
Pears	IMB
Butterscotch Pudding	RSB
Pineapple-Grapefruit Drink	R
Grape Drink	R

Day 2 Meal C

Turkey and Gravy	WP
Chicken Stew	RSP
Apricots	IMB
Jellied Candy	IMB
Orange-Grapefruit Drink	R

LMP - Blue Velcro

Day 1 Meal C

Cream of Chicken Soup	RSB
Ham Salad - Bread	WP
Jellied Candy	IMB
Chocolate Pudding	RSB
Grapefruit Drink	R
Pineapple-Grapefruit Drink	R

Day 2 Meal A

Peaches	R
Corn Flakes	R
Canadian Bacon & Applesauce	RSB
Cocoa	R
Orange Drink	R

Day 2 Meal B

Beef and Gravy	WP
Butterscotch Pudding	RSB
Pineapple-Grapefruit Drink	R
Grapefruit Drink	R

Day 2 Meal C

Turkey and Gravy	WP
Chicken Stew	RSB
Fruit Cocktail	R
Jellied Candy	IMB
Orange-Grapefruit Drink	R

2 Spoons

IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon-Bowl
WP = Wet Pack

TABLE 23

APOLLO 13 - (LOVELL, CDR.)

Meal	Day 1*, 5**, 9		Day 2, 6, 10		Day 3, 7, 11		Day 4, 8	
A	Peaches	RSB	Pears	IMB	Peaches	IMB	Apricots	IMB
	Canadian Bacon & Applesauce	RSB	Bacon Squares (8)	IMB	Canadian Bacon & Applesauce	RSB	Bacon Squares (8)	IMB
	Bacon Squares (8)	IMB	Scrambled Eggs	RSB	Sugar Coated Corn Flakes	RSB	Scrambled Eggs	RSB
	Cocoa	R	Grapefruit Drink	R	Cocoa	R	Orange-G.F. Drink	R
	Orange Drink	R	Coffee (B)	R	Grape Drink	R	Coffee (B)	R
B	Salmon Salad	RSB	Frankfurters	WP	Cream of Chicken Soup	RSB	Chicken & Rice Soup	RSB
	Beef & Gravy	WP	Cranberry-Orange	RSB	Bread Slice Sandwich Spread***	WP	Meatballs with Sauce	WP
	Jellied Candy	IMB	Chocolate Pudding	RSB	Chocolate Bar	IMB	Caramel Candy	IMB
	Grape Drink	R	Orange-G.F. Drink	R	P.A.-G.F. Drink	R	Orange Drink	R
C	Pea Soup	RSB	Shrimp Cocktail	RSB	Chicken Stew	RSB	Tuna Salad	RSB
	Chicken & Rice	RSB	Pork & Scalloped Potatoes	RSB	Turkey & Gravy	WP	Beef Stew	RSB
	Date Fruitcake (4)	DB	Apricots	IMB	Butterscotch Pudding	RSB	Banana Pudding	RSB
	P.A.-G.F. Drink	R	Orange Drink	R	Grapefruit Drink	R	Grape Punch	R
Days Total Calories	2106		2073		2183		2043	

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

* Day 1 consists of Meal B and C only; extra meal consists of: Ham & Cheese Sandwich (frozen), Caramel Candy, Orange-G.F. Drink

** Day 5 consists of Meal A only

*** Bread: Cheese, Rye, White
Sandwich Spreads: Chicken, Ham, Tuna Salad, Cheddar Cheese Spread, Peanut Butter, Jelly

TABLE 24

APOLLO 13 - (HAISE - LMP)

Meal	Day 1*, 5**, 9		Day 2, 6, 10		Day 3, 7, 11		Day 4, 8	
A	Peaches	RSB	Pears	IMB	Peaches	IMB	Apricots	IMB
	Sausage Patties	R	Bacon Squares (8)	IMB	Sugar Coated Corn Flakes	RSB	Bacon Squares (8)	IMB
	Cinnamon Toast (4)	DB	Scrambled Eggs	RSB	Graham Cracker Cubes (4)	DB	Scrambled Eggs	RSB
	Orange Drink	R	Cocoa	R	Grape Drink	R	Cocoa	R
	Coffee (B)	R	Grapefruit Drink	R	Coffee (B)	R	Orange-G.F. Drink	R
B	Chicken Salad	RSB	Frankfurters	WP	Cream of Chicken Soup	RSB	Chicken & Rice Soup	RSB
	Beef & Gravy	WP	Cranberry-Orange	RSB	Bread Slice Sandwich Spread ***	WP	Meatballs with Sauce	WP
	Jellied Candy	IMB	Chocolate Pudding	RSB	Chocolate Bar	IMB	Caramel Candy	IMB
	Grape Drink	R	Orange-G.F. Drink	R	P.A.-G.F. Drink	R	Orange Drink	R
C	Potato Soup	RSB	Spaghetti with Meat	RSB	Chicken Stew	RSB	Tuna Salad	RSB
	Chicken & Rice	RSB	Pork and Scalloped Potatoes	RSB	Turkey & Gravy	WP	Beef Stew	RSB
	Date Fruitcake (4)	DB	Gingerbread (4)	DB	Butterscotch Pudding	RSB	Chocolate Pudding	RSB
	P.A.-G.F. Drink	R	Orange Drink	R	Grapefruit Drink	R	Grape Punch	R
Days Total Calories		2079		2198		2165		2070

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

* Day 1 consists of Meal B and C only; extra meal consists of: Smoked Turkey Sandwich (frozen), Caramel Candy, Grape Drink

** Day 5 consists of Meal A only

*** Bread: Cheese, Rye, White
Sandwich Spread: Chicken, Ham, Tuna Salad, Cheddar Cheese Spread, Peanut Butter, Jelly.

TABLE 25

APOLLO 13 - (MATTINGLY, CMP)

Meal	Day 1*, 5**, 9		Day 2, 6, 10		Day 3, 7, 11		Day 4, 8	
A	Peaches	RSB	Pears	IMB	Peaches	IMB	Apricots	IMB
	Canadian Bacon & Applesauce	RSB	Bacon Squares (8)	IMB	Canadian Bacon & Applesauce	RSB	Bacon Squares (8)	IMB
	Bacon Squares (8)	IMB	Scrambled Eggs	RSB	Sugar Coated Corn Flakes	RSB	Scrambled Eggs	RSB
	Cinnamon Toast (4)	DB	Grapefruit Drink	R	Grape Drink	R	Orange-G.F. Drink	R
	Orange Drink	R	Coffee (B)	R	Coffee (B)	R	Coffee (B)	R
	Coffee (B)	R						
B	Potato Soup	RSB	Frankfurters	WP	Cream of Chicken Soup	RSB	Chicken & Rice Soup	RSB
	Beef & Gravy	WP	Cranberry-Orange	RSB	Bread Slice		Meatballs with Sauce	WP
	Jellied Candy	IMB	Chocolate Pudding	RSB	Sandwich Spread ***	WP	Caramel Candy	IMB
	Brownies (4)	DB	Orange-G.F. Drink	R	Chocolate Bar	IMB	Orange Drink	R
	Grape Drink	R			P.A.-G.F. Drink	R		
C	Pea Soup	RSB	Spaghetti & Meat	RSB	Chicken Stew	RSB	Spaghetti & Meat	RSB
	Chicken & Rice	RSB	Pork & Scalloped Potatoes	RSB	Turkey & Gravy	WP	Beef Stew	RSB
	Date Fruitcake (4)	DB	Apricots	IMB	Butterscotch Pudding	RSB	Banana Pudding	RSB
	P.A.-G.F. Drink	R	Orange Drink	R	Grapefruit Drink	R	Grape Punch	R
Days Total Calories		2113		2124		1944		2011

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

* Day 1 consists of Meal B and C only: extra meal consists of: Ham & Cheese Sandwich (frozen), Caramel Candy, Orange-G.F. Drink
** Day 5 consists of Meal A, B and C
*** Bread: Cheese, Rye, White
Sandwich Spreads: Chicken, Ham, Tuna Salad, Cheddar Cheese Spread, Peanut Butter, Jelly.

TABLE 26

APOLLO 13 - LM-7 MENU

CDR
LMP

2 2/3 MAN DAYS
(8 Meals)

Day 1 Meal B

Cream of Chicken Soup	RSB
Bread Slice	
Tuna Salad Sandwich Spread	WP
Peaches	IMB
Caramel Candy	IMB
P.A.-G.F. Drink	R
Orange Drink	R

Total Meal's Calories 875

Day 1 Meal C

Beef & Gravy	WP
Pears	IMB
Butterscotch Pudding	RSB
Orange-G.F. Drink	R
Grape Drink	R

Total Meal's Calories 825

Day 2 Meal A

Peaches	RSB
Bacon Squares (8)	IMB
Sugar Coated Corn Flakes	RSB
Cocoa	R
Orange Drink	R

Total Meal's Calories 661

Day 2 Meal B

Turkey & Gravy	WP
Chicken & Rice	RSB
Apricots	IMB
Date Fruitcake (4)	DB
Grapefruit Drink	R

Total Meal's Calories 682

Spoons 2

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

TABLE 27

APOLLO 13

PANTRY STOWAGE

Day 6 through Day 10 P/N: 14-0123

BREAKFAST ITEMS	UNITS
Corn Flakes (RSB)	3
Toasted Oats (RSB)	3
Canadian Bacon & Applesauce	3
Fruit Cocktail (R)	3
Peaches (RSB)	6
Bacon Squares (8)	9
Sausage Patties (R)	2
Scrambled Eggs (RSB)	6
Cinnamon Toast (4)	3
	38

CUBES/CANDY	UNITS
Jellied Candy (4)	3
Chocolate Bar (1)	3
Caramel Candy (4)	9
Gingerbread (4)	3
Date Fruitcake (4)	3
Cheese Crackers (4)	3
Pecans	3
Brownies (4)	3
	30

SALADS/SOUPS	UNITS
Salmon Salad (RSB)	2
Tuna Salad (RSB)	2
Shrimp Cocktail (RSB)	2
Cream of Tomato Soup (RSB)	3
Chicken & Rice Soup (RSB)	3
	12

DESSERTS	UNITS
Chocolate Pudding (RSB)	3
Banana Pudding (RSB)	3
Butterscotch Pudding (RSB)	3
Cranberry-Applesauce (RSB)	3
Cranberry-Orange (RSB)	3
	15

WET PACK FOOD	UNITS
Beef & Gravy	3
Turkey & Gravy	3
Meat Balls	3
Frankfurters	3
	12

DRIED FRUIT	UNITS
Peaches	6
Apricots	6
Pears	6
	18

MEAT ITEMS	UNITS
Chicken & Rice (RSB)	3
Pork & Scalloped Potatoes (RSB)	3
Chicken Stew (RSB)	3
Spaghetti W/Meat Sauce (RSB)	3
Beef Stew (RSB)	3
Beef & Gravy (RSB)	3
	18

SANDWICH SPREAD/BREAD	UNITS
Chicken Salad (8 oz.)	1
Tuna Salad (8 oz.)	1
Cheddar Cheese (2 oz.)	3
Peanut Butter	6
Jelly	3
Bread (Slice)	9
Catsup	3
Mustard	3

BEVERAGES	UNITS
Coffee (B)	24
Cocoa	6
Orange Juice	20
Grapefruit Drink	3
Orange-Grapefruit Drink	3
Pineapple-Grapefruit Drink	3
Grape Drink	3
Grape Punch	3
	65

ACCESSORIES	UNITS
Chewing Gum	15
Wet skin cleaning towels	20
***Contingency Feeding System	1
3 food restrainer pouches	
3 beverage packages	
1 valve adapter (pontube)	
Germicidal Tablets (42)	2
Index Card	1

TABLE 28

APOLLO 14 (SHEPARD - CDR)

MEAL	Day 1*, 5**		Day 2		Day 3		Day 4	
A	Peaches	RSB	Fruit Cocktail	R	Peaches	WP	Mixed Fruit	WP
	Scrambled Eggs	RSB	Sausage Patties	R	Scrambled Eggs	RSB	Canadian Bacon & Applesauce	RSB
	Bacon Squares (8)	IMB	Spiced Fruit Cereal	RSB	Bacon Squares (8)	IMB	Cornflakes	RSB
	Grapefruit Drink	R	Orange Drink	R	Grape Drink	R	P.A.-G.F. Drink	R
	Coffee, Black	R	Coffee, Black	R	Coffee, Black	R	Coffee, Black	R
B	Chicken and Rice	RSB	Turkey & Gravy	WP	Pea Soup	RSB	Chicken & Rice Soup	RSB
	Applesauce	RSB	Cranberry-Orange Sauce	RSB	Bread Slices (2)		Meatballs w/Sauce	WP
	Chocolate Bar	IMB	Pineapple Fruitcake (4)	DB	Sandwich Spread***	WP	Lemon Pudding	WP
	Orange-G.F. Drink	R	Grape Punch	R	Butterscotch Pudding	RSB	Graham Cracker Cubes (4)	DB
					Grapefruit Drink	R	Grape Punch	R
C	Cream of Tomato Soup	RSB	Cream of Chicken Soup	RSB	Lobster Bisque	RSB	Beef & Gravy	WP
	Spaghetti & Meat Sauce	RSB	Frankfurters	WP	Beef Stew	RSB	Chicken & Vegetables	RSB
	Peach Ambrosia	RSB	Banana Pudding	RSB	Beef Sandwiches (4)	DB	Chocolate Pudding	RSB
	Cheese Cracker Cubes (4)	DB	Brownies (4)	DB	Caramel Candy	IMB	Sugar Cookie Cubes (4)	DB
	Grape Drink	R	P.A.-G.F. Drink	R	Orange-G.F. Drink	R	Grapefruit Drink	R
Days Total Calories		1748		2272		2157		2098

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

*Day 1 consists of Meal C only.
**Day 5 consists of Meal A only.
***Bread: Cheese, Rye, White
Sandwich Spreads: Chicken, Ham, Tuna Salad, Cheddar Cheese Spread, Peanut Butter, Jelly

TABLE 29

APOLLO 14 (MITCHELL - LMP)

MEAL	Day 1*, 5**		Day 2		Day 3		Day 4	
A	Peaches	RSB	Fruit Cocktail	R	Peaches	WP	Mixed Fruit	WP
	Scrambled Eggs	RSB	Apricot Cereal Cubes (4)	DB	Scrambled Eggs	RSB	Canadian Bacon & Applesauce	RSB
	Bacon Squares (8)	IMB	Spiced Fruit Cereal	RSB	Bacon Squares (8)	IMB	Cornflakes	RSB
	Grapefruit Drink	R	Orange Drink	R	Grape Drink	R	P.A.-G.F. Drink	R
	Coffee, Black	R	Coffee, Black	R	Coffee, Black	R	Coffee, Black	R
B	Beef Pot Roast	RSB	Beef & Gravy	WP	Pea Soup	RSB	Corn Chowder	RSB
	Applesauce	RSB	Cranberry-Orange Sauce	RSB	Bread Slices (2)		Meatballs w/Sauce	WP
	Jellied Fruit Candy	IMB	Pineapple Fruitcake (4)	DB	Sandwich Spread***	WP	Vanilla Pudding	WP
	Orange-G.F. Drink	R	Grape Punch	R	Butterscotch Pudding	RSB	Chocolate Bar	IMB
					Grapefruit Drink	R	Grape Punch	R
C	Cream of Tomato Soup	RSB	Cream of Chicken Soup	RSB	Lobster Bisque	RSB	Beef & Gravy	WP
	Pork & Scalloped Potatoes	RSB	Frankfurters	WP	Beef Stew	RSB	Potato Soup	RSB
	Peach Ambrosia	RSB	Banana Pudding	RSB	Beef Sandwiches (4)	DB	Chocolate Pudding	RSB
	Cheese Cracker Cubes (4)	DB	Brownies (4)	DB	Apricots	IMB	Sugar Cookie Cubes (4)	DB
	Grape Drink	R	P.A.-G.F. Drink	R	Caramel Candy	IMB	P.A.-G.F. Drink	R
					Cocoa	R		
Days Total Calories		1835		2139		2268		2365

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

*Day 1 consists of Meal C only.
**Day 5 consists of Meal A only.
***Bread: Cheese, Rye, White
Sandwich Spreads: Chicken, Ham, Tuna Salad, Cheddar Cheese Spread, Peanut Butter, Jelly

TABLE 30

APOLLO 14 (ROOSA - CMP)

MEAL	Day 1*, 5**		Day 2		Day 3		Day 4	
A	Peaches	RSB	Fruit Cocktail	R	Peaches	WP	Mixed Fruit	WP
	Scrambled Eggs	RSB	Cinnamon Toasted Bread (4)	DB	Scrambled Eggs	RSB	Canadian Bacon & Applesauce	RSB
	Bacon Squares (8)	IMB	Pork & Scalloped Potatoes	RSB	Bacon Squares (8)	IMB	Cornflakes	RSB
	Orange Drink	R	Orange-G.F. Drink	R	P.A.-Orange Drink	R	Orange-G.F. Drink	R
	Cocoa	R	Cocoa	R	Cocoa	R	Cocoa	R
B	Pea Soup	RSB	Corn Chowder	RSB	Pea Soup	RSB	Chicken & Rice Soup	RSB
	Chicken Salad	RSB	Turkey & Gravy	WP	Bread Slices (2)		Meatballs w/Sauce	WP
	Turkey Bites (4)	DB	Cheese Sandwiches (4)	DB	Sandwich Spread***	WP	Chicken Sandwiches (6)	DB
	Orange-G.F. Drink	R	P.A.-Orange Drink	R	Creamed Chicken Bites (6)	DB	Vanilla Pudding	WP
					Orange Drink	R	P.A.-G.F. Drink	R
C	Cream of Tomato Soup	RSB	Potato Soup	RSB	Lobster Bisque	RSB	Beef & Gravy	WP
	Tuna Salad	RSB	Meatballs w/Sauce	WP	Beef Stew	RSB	Shrimp Cocktail	RSB
	Spaghetti & Meat Sauce	RSB	Chicken and Rice	RSB	Potato Salad	RSB	Chicken Stew	RSB
	Cheese Cracker Cubes (4)	DB	Peanut Cubes (4)	DB	Beef Sandwiches (4)	DB	Sugar Cookie Cubes (4)	DB
	Orange Drink	R	P.A.-G.F. Drink	R	Orange-G.F. Drink	R	Cocoa	R
Days Total Calories		2006		2128		2013		2138

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

*Day 1 consists of Meal C only.
**Day 5 consists of Meals A, B and C.
***Bread: Cheese, Rye, White
Sandwich Spreads: Chicken, Ham, Tuna Salad, Cheddar Cheese Spread, Peanut Butter, Jelly

TABLE 31

APOLLO 14/LM MENU

CDR - Red Velcro
LMP - Blue Velcro

2 2/3 MAN DAYS (8 Meals)

Day 1 Meal B

Cream of Tomato Soup	RSB
Bread Slice	
Ham Salad Sandwich Spread	WP
Caramel Candy	IMB
Pineapple-Grapefruit Drink	R
Grapefruit Drink	R
Total Meals Calories	906

Day 1 Meal C

Beef & Gravy	WP
Cheese Cracker Cubes (4)	DB
Apricots	IMB
Butterscotch Pudding	RSB
Orange-Grapefruit Drink	R
Grape Punch	R
Total Meals Calories	875

Day 2 Meal A

Peaches	RSB
Bacon Squares (8)	IMB
Sugar Coated Cornflakes	RSB
Cocoa	R
Orange-Pineapple Drink	R
Total Meals Calories	668

Day 2 Meal B

Lobster Bisque	RSB
Meatballs w/Sauce	WP
Chocolate Bar	IMB
Pineapple Fruitcake (4)	DB
Grapefruit Drink	R
Total Meals Calories	880

Spoons 2

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

TABLE 31 CONTINUED

APOLLO 14

PANTRY STOWAGE
DAY 6 THROUGH DAY 10

BEVERAGES	QTY
Cocoa	6
Coffee (B)	16
Grape Drink	2
Grapefruit Drink	6
Grape Punch	2
Orange-Grapefruit Drink	6
Orange Juice	20
Pineapple-Grapefruit Drink	6
Pineapple-Orange Drink	6
	70

BREAKFAST ITEMS	
Bacon Squares (8) (IMB)	12
Cinn. Toasted Bread Cubes (4)	3
Canadian Bacon & Applesauce (RSB)	3
Cornflakes (RSB)	3
Fruit Cocktail (R)	3
Sausage Patties (R)	2
Scrambled Eggs (RSB)	6
Peaches (RSB)	3
Spiced Fruit Cereal (RSB)	3
Apricot (IMB)	3
Peaches (IMB)	3
	44

CUBES/CANDY	
Brownies (4)	2
Caramel Candy (4)	2
Chocolate Bar	2
Creamed Chicken Bites (6)	3
Cheese Cracker (4)	6
Cheese Sandwiches (4)	3
Beef Sandwiches (4)	3
Jellied Fruit Candy	2
Jerky	3
Peanut Cubes (4)	2
Pecans (6)	3
Pineapple Fruitcake (4)	2
Sugar Cookies (4)	3
Turkey Bites (4)	3
	39

DESSERTS	
Applesauce (RSB)	2
Banana Pudding (RSB)	2
Butterscotch Pudding (RSB)	2
Chocolate Pudding (RSB)	2
Cranberry-Orange Sauce (RSB)	3
Peach Ambrosia (RSB)	4
	15

SALADS/SOUPS	QTY
Chicken & Rice Soup (RSB)	2
Lobster Bisque (RSB)	3
Pea Soup (RSB)	3
Potato Soup (RSB)	3
Shrimp Cocktail (RSB)	2
Tomato Soup (RSB)	3
Tuna Salad (RSB)	2
	18

SANDWICH SPREADS/BREAD	
Bread (slice)	6
Catsup	3
Cheddar Cheese (2 oz.)	3
Chicken Salad (8 oz.)	1
Ham Salad (8 oz.)	1
Jelly	3
Mustard	3
Peanut Butter	3
	23

MEAT ITEMS	
Beef Pot Roast (RSB)	3
Beef & Vegetables (RSB)	3
Beef Stew (RSB)	3
Chicken & Rice (RSB)	2
Chicken & Vegetables (RSB)	2
Chicken Stew (RSB)	2
Pork & Scalloped Potatoes (RSB)	2
Spaghetti w/Meat Sauce (RSB)	3
	20

WET PACK FOOD	
Beef & Gravy	4
Frankfurters	2
Meatballs w/Sauce	4
Turkey & Gravy	2
	12

ACCESSORIES	
Chewing Gum	15
Wet skin cleaning towels	20
Contingency Feeding System	1
3 food restrainer pouches	
3 beverage packages	
1 valve adapter (pontube)	
Germicidal Tablets (42)	2
Index Card	1

TABLE 32

APOLLO 15 - CSM-MENU

David R. Scott, CDR
James B. Irwin, LMP

MEAL	DAY 1*, 5**, 9		DAY 2, 10		DAY 3, 11**		DAY 4, 8*	
A	Peaches	RSB	Fruit Cocktail	RSB	Peaches	WP	Mixed Fruit	WP
	Scrambled Eggs	RSB	Sausage Patties	R	Scrambled Eggs	RSB	Canadian Bacon & Applesauce	RSB
	Bacon Squares (8)	IMB	Spiced Fruit Cereal	RSB	Bacon Squares (8)	IMB	Cornflakes	RSB
	Grapefruit Drink	R	Orange Drink	R	Grape Drink	R	Pineapple-Grapefruit Drink	R
	Cocoa	R	Cocoa	R	Cocoa	R	Cocoa	R
B	Hamburger	WP	Turkey & Gravy	WP	Lobster Bisque	RSB	Chicken & Rice Soup	RSB
	Pea Soup	RSB	Cranberry-Orange	RSB	Bread Slices (2)		Meatballs w/Sauce	WP
	Salmon Salad	RSB	Pineapple Fruitcake (4)	DB	Sandwich Spread	WP	Lemon Pudding	WP
	Applesauce	RSB	Vanilla Pudding	WP	Butterscotch Pudding	RSB	Sugar Cookie Cubes (4)	DB
	Cheese Cracker Cubes (4)	DB	Citrus Beverage	R	Pineapple-Orange Drink	R	Grape Punch	R
	Orange-Grapefruit Drink	R						
C	Cream Tomato Soup	RSB	Cream Chicken Soup	RSB	Shrimp Cocktail	RSB	Beef & Gravy	WP
	Spaghetti & Meat	RSB	Frankfurters	WP	Beef Steak	WP	Pork & Scalloped Potatoes	RSB
	Peach Ambrosia	RSB	Banana Pudding	RSB	Peaches	IMB	Chocolate Pudding	RSB
	Chocolate Bar	IMB	Brownies (4)	DB	Caramel Candy	IMB	Apricots	IMB
	Grape Drink	R	Pineapple-Grapefruit Drink	R	Orange-Grapefruit Drink	R	Grapefruit Drink	R
	Calories/Day	2372		2550		2314		2328

*Day 1 and Day 8 consists of Meal C only
**Day 5 and Day 11 consists of Meal A only
DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

TABLE 33

APOLLO 15 - CSM-MENU   Alfred M. Worden, CMP -

MEAL	DAY 1*, 5, 9		DAY 2, 6, 10		DAY 3, 7, 11**		DAY 4, 8	
A	Peaches	RSB	Fruit Cocktail	RSB	Peaches	WP	Mixed Fruit	WP
	Scrambled Eggs	RSB	Sausage Patties	R	Scrambled Eggs	RSB	Canadian Bacon & Applesauce	RSB
	Bacon Squares (8)	IMB	Spiced Fruit Cereal	RSB	Bacon Squares (8)	IMB	Cornflakes	RSB
	Grapefruit Drink	R	Orange Drink	R	Grape Drink	R	Pineapple-Grapefruit Drink	R
	Cocoa	R	Cocoa	R	Cocoa	R	Cocoa	R
B	Hamburger	WP	Turkey & Gravy	WP	Lobster Bisque	RSB	Chicken & Rice Soup	RSB
	Pea Soup	RSB	Cranberry-Orange	RSB	Bread Slices (2)		Meatballs w/Sauce	WP
	Salmon Salad	RSB	Pineapple Fruitcake (4)	DB	Sandwich Spread	WP	Lemon Pudding	WP
	Applesauce	RSB	Vanilla Pudding	WP	Butterscotch Pudding	RSB	Sugar Cookie Cubes (4)	DB
	Cheese Cracker Cubes (4)	DB	Citrus Beverage	R	Pineapple-Orange Drink	R	Grape Punch	R
	Orange-Grapefruit Drink	R						
C	Cream Tomato Soup	RSB	Cream Chicken Soup	RSB	Shrimp Cocktail	RSB	Beef & Gravy	WP
	Spaghetti & Meat	RSB	Frankfurters	WP	Beef Steak	WP	Pork & Scalloped Potatoes	RSB
	Peach Ambrosia	RSB	Banana Pudding	RSB	Peaches	IMB	Chocolate Pudding	RSB
	Chocolate Bar	IMB	Brownies (4)	DB	Caramel Candy	IMB	Apricots	IMB
	Grape Drink	R	Pineapple-Grapefruit Drink	R	Orange-Grapefruit Drink	R	Grapefruit Drink	R
	Calories /Day	2372		2550		2314		2328

*Day 1 consists of Meal C only
**Day 11 consists of Meal A only

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

TABLE 34

APOLLO 15 - LM MENU

David R. Scott, CDR
James B. Irwin, LMP

MEAL	DAY 5		DAY 6		DAY 7		DAY 8	
A			Peaches	RSB	Apricots	IMB	Peaches	IMB
			Bacon Squares (8)	DB	Beef Steak	WP	Bacon Squares (8)	DB
			Scrambled Eggs	RSB	Sausage Patties	R	Cinn. Toasted Bread (6)	DB
			Graham Cracker Cubes (6)	DB	Cornflakes	RSB	Pork & Scalloped Potatoes	RSB
			Orange-Pineapple Drink	R	Grapefruit Drink	R	Beef Steak	WP
			Cocoa	R	Cocoa	R	Orange-Pineapple Drink	R
							Cocoa	R
B	Cream Tomato Soup	RSB	Salmon Salad	RSB	Shrimp Cocktail	RSB	Tuna Salad	RSB
	Bread Slice (2) and		Frankfurters	WP	Ham & Applesauce	RSB	Chicken & Rice	RSB
	Ham Salad Spread	WP	Chocolate Bar	IMB	Meatballs w/Sauce	WP	Turkey & Gravy	WP
	Caramel Candy	IMB	Peacans	IMB	Brownies (6)	DB	Chocolate Pudding	RSB
	Pineapple-Grapefruit Drink	R	Peach Ambrosia	RSB	Cheese Crackers (6)	DB	Grape Punch	R
	Grapefruit Drink	R	Orange-Grapefruit Drink	R	Orange Drink	R		
					Grape Drink	R		

In-Suit Food Bar Assembly (1)	6 ea
In-Suit Drinking Device (1)	2 ea
Spoon Assembly (2)	1 ea
Germicidal Tablets Pouch (42)	1 ea
Beverages (6)	

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

TABLE 35
APOLLO 16 CSM MENU - (CDR. JOHN W. YOUNG)

MEAL	Day 1*, 5**, 9, 13**		Day 2, 10		Day 3, 11		Day 4, 8***, 12	
A	Peaches+	WP	Fruit Cocktail	R	Peaches	RSB	Mixed Fruit+	WP
	Scrambled Eggs	RSB	Sausage Patties	R	Scrambled Eggs	RSB	Ham Steak	WP
	Bacon Squares(8)	IMB	Spiced Fruit Cereal	RSB	Bacon Squares(8)	IMB	Cornflakes	RSB
	Grits	RSB	Orange Juice	R	Grits	RSB	White Bread(1) Jelly++	WP
	Orange Juice	R	Cocoa w/K	R	Orange Juice	R	Orange Juice	R
	Cocoa w/K	R			Coffee (Day 11) w/K	R	Cocoa w/K	R
	(+Peaches-Day 13	RSB)			Cocoa w/K	R	(+Fruit Cocktail-Day 12	R
							(++Delete on Day 12)	
B	Chicken & Rice Soup	RSB	Corn Chowder	RSB	Lobster Bisque	RSB	Pea Soup	RSB
	Hamburger & White Bread(1)	WP	Turkey & Gravy	WP	Bread Rye (2)		Meatballs w/Sauce	WP
	Pears	IMB	Vanilla Pudding	WP	Tuna Spread	WP	Lemon Pudding+	WP
	Instant Breakfast	R	White Bread(1) & Peanut Butter	WP	Cherry Food Bar(2)	IMB	Sugar Cookies(4)	DB
	Cereal Bar	DB	Apple Food Bar(2)	IMB	Graham Cracker Cubes (6)	DB	Peaches	IMB
	Citrus Beverage w/K	R	Orange Drink w/K	R	Cocoa w/K	R	Orange-Grapefruit Drk w/K	R
							(+Pork & Scalloped Potatoes-Day 8 & 12	RSB
C	Cream Tomato Soup	RSB	Cream Potato Soup	RSB	Romaine Soup	RSB	Beef & Gravy	WP
	Spaghetti/Meat Sauce	RSB	Frankfurters(4)	WP	Beef Steak	WP	Chicken Stew	RSB
	Peach Ambrosia	RSB	Chocolate Pudding	RSB	Chicken & Rice	RSB	Butterscotch Pudding	RSB
	Brownies(4)	DB	Orange-Grapefruit Drink w/K	R	Pin. Fruitcake(4)	DB	Chocolate Bar	DB
	Pecans(6)	DB			Pecans (6)	DB	Gingerbread (4)	DB
	Cocoa w/K	R			Grape Drink w/K	R	Citrus Beverage w/K	R

* Meal C only
** Meal A only
*** Meal B and C only

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack
SBD = Skylab Beverage Dispenser
RC = Rehydratable Can

3B SKYLAB MEAL

Turkey & Rice Soup	RC
Rye Bread (2) Chicken Spread (1/3)	WP
Peaches	WP
Peanuts	CAN
S/L Grapefruit Crystals w/K	SBD

TABLE 36. APOLLO 16 LM MENU (CDR, JOHN W. YOUNG)

MEAL	Day 5		MEAL	Day 6		MEAL	Day 7		MEAL	Day 8	
B	Cream Tomato Soup	RSB	A	Peaches (39 g)	IMB	A	Peaches (39 g)	IMB	A	Peaches (39 g)	IMB
	Rye Bread (2)			Ham Steak	WP		Beef Steak	WP		Ham Steak	WP
	Tuna Spread			Scrambled Eggs	RSB		Bacon Squares (8)	IMB		Scrambled Eggs	RSB
	Apple Food Bar (2)	IMB		Cinn. Toasted Bread Cubes (6)	DB		Spiced Fruit Cereal	RSB		Cereal Bar	DB
	Chocolate Bar	DB		Instant Breakfast	R		Instant Breakfast	R		Apricot Cereal Cubes (6)	DB
	Orange-Grapefruit Beverage	R		Grapefruit Drink	R		Grapefruit Drink	R		Orange Beverage	R
				Apricot Food Bar (2)	IMB		Cherry Food Bar (2)	IMB		Cocoa	R
C	Shrimp Cocktail	RSB	B	Pea Soup	RSB	B	Romaine Soup	RSB		—	
	Turkey & Gravy	WP		Salmon Salad	RSB		Tuna Salad	RSB			
	Chocolate Pudding	RSB		Frankfurters (4)	WP		Meatballs w/Sauce	WP			
	Graham Cracker Cubes (6)	DB		Peach Ambrosia	RSB		Chicken & Rice	RSB		—	
	Cocoa	R		Pears	IMB		Butterscotch Pudding	RSB			
	Citrus Beverage	R		Cereal Bar	DB		Gingerbread (6)	DB			
				Orange-Grapefruit Beverage	R		Citrus Beverage	R			
				Cocoa	R		Cocoa	R			

In-Suit Food Bar Assembly 6 ea P/N:
In-Suit Beverage Assembly 4 ea P/N:
Spoon Assembly (2) 1 ea P/N: 14-0144-01
Germicidal Tablets Pouch (42) 1 ea P/N: 14-02166
Germicidal Tablets Pouch (20) 1 ea P/N:

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

TABLE 37. APOLLO 16 CSM MENU (LMP, CHARLES M. DUKE)

MEAL	Day 1*, 5**, 9, 13**		Day 2, 10		Day 3, 11		Day 4, 8***, 12	
A	Peaches+	WP	Fruit Cocktail	R	Peaches	RSB	Mixed Fruit+	WP
	Scrambled Eggs	RSB	Sausage Patties	R	Scrambled Eggs	RSB	Ham Steak	WP
	Bacon Squares(8)	IMB	Spiced Fruit Cereal	RSB	Bacon Squares (8)	IMB	Cornflakes	RSB
	Grits	RSB	Orange Juice	R	Grits	RSB	White Bread (1) Jelly++	WP
	Orange Juice	R	Cocoa w/K	R	Orange Juice	R	Orange Juice	R
	Cocoa w/K	R			Cocoa w/K	R	Cocoa w/K	R
	(+Peaches-Day 13	RSB)					(+Fruit Cocktail-Day 12	R)
							(++Delete on Day 12)	
B	Chicken & Rice Soup	RSB	Corn Chowder	RSB	Lobster Bisque	RSB	Pea Soup	RSB
	Hamburger & White Bread (1)	WP	Turkey & Gravy	WP	Bread Rye (2)		Meatballs w/Sauce	WP
	Pears	IMB	Vanilla Pudding	WP	Tuna Spread	WP	Lemon Pudding+	WP
	Inst. Breakfast	R	White Bread (1) & Peanut Butter	WP	Cherry Food Bar (2)	IMB	Sugar Cookies (4)	DB
	Cereal Bar	DB	Apple Food Bar(2)	IMB	Graham Cracker Cubes (6)	DB	Peaches	IMB
	Citrus Beverage w/K	R	Orange Drink w/K	R	Citrus Beverage w/K	R	Orange-Grapefruit Drk w/K	R
							(+Pork & Scalloped Potatoes-Day 8 & 12	RSB)
C	Cream Tomato Soup	RSB	Cream Potato Soup	RSB	Romaine Soup	RSB	Beef & Gravy	WP
	Spaghetti/Meat Sauce	RSB	Frankfurters (4)	WP	Beef Steak	WP	Chicken Stew	RSB
	Peach Ambrosia	RSB			Chicken & Rice	RSB	Butterscotch Pudding	RSB
	Apricot Cereal Cubes (4)	DB	Chocolate Pudding	RSB	Pin. Fruitcake (4)	DB	Chocolate Bar	DB
	Pecans (6)	DB	Orange-Grapefruit Drink w/K	R	Pecans (6)	DB	Gingerbread (4)	DB
	Cocoa w/K	R			Grape Drink w/K	R	Citrus Beverage w/K	R

* Meal C only
** Meal A only
*** Meal B and C only

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack
RC = Rehydratable Can
SBD = Skylab Beverage Dispenser

3B SKYLAB MEAL	
Turkey & Rice Soup	RC
Rye Bread (2)	
Chicken Spread (1/3)	WP
Peaches	WP
Peanuts	CAN
S/L Orange Crystals w/K	SBD

TABLE 38. APOLLO 15 LM MENU (LMP, CHARLES M. DUKE)

MEAL	Day 5			Day 6			Day 7			Day 8	
B	Cream Tomato Soup	RSB	A	Peaches (39 g)	IMB	A	Peaches (39 g)	IMB	A	Peaches (39 g)	IMB
	Rye Bread (2)			Ham Steak	WP		Beef Steak	WP		Ham Steak	WP
	Tuna Spread	WP		Scrambled Eggs	RSB		Bacon Squares (8)	IMB		Scrambled Eggs	RSB
	Apple Food Bar (2)	IMB		Cinn. Toasted Bread Cubes (6)	DB		Spiced Fruit Cereal	RSB		Cereal Bar	DB
	Chocolate Bar	DB		Instant Breakfast	R		Instant Breakfast	R		Apricot Cereal Cubes (6)	DB
	Orange-Grapefruit Beverage	R		Orange-Grapefruit Beverage	R		Orange-Grapefruit Beverage	R		Orange Beverage	R
				Lemon Food Bar (2)	IMB		Cherry Food Bar (2)	IMB		Cocoa	R
C	Shrimp Cocktail	RSB	B	Pea Soup	RSB	B	Romaine Soup	RSB			
	Turkey & Gravy	WP		Salmon Salad	RSB		Tuna Salad	RSB			
	Chocolate Pudding	RSB		Frankfurters (4)	WP		Meatballs w/Sauce	WP			
	Graham Cracker Cubes (6)	DB		Peach Ambrosia	RSB		Chicken & Rice	RSB			
	Cocoa	R		Pears	IMB		Butterscotch Pudding	RSB			
	Citrus Beverage	R		Cereal Bar	DB		Gingerbread (6)	DB			
				Citrus Beverage	R		Citrus Beverage	R			
				Cocoa	R		Cocoa	R			

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack

TABLE 39. APOLLO 16 CSM MENU (CMP, THOMAS K. MATTINGLY)

MEAL	Day 1*, 5, 9, 13*		Day 2, 6, 10		Day 3, 7, 11		Day 4, 8, 12	
A	Peaches+	WP	Fruit Cocktail	R	Peaches	RSB	Mixed Fruit+	WP
	Scrambled Eggs	RSB	Sausage Patties	R	Scrambled Eggs	RSB	Ham Steak	WP
	Bacon Squares(8)	IMB	Spiced Fruit Cereal	RSB	Bacon Squares(8)	IMB	Cornflakes	RSB
	Orange Juice	R	Orange Juice	R	Grits	RSB	White Bread (1), Jelly++	WP
	Coffee w/K	R	Coffee w/K	R	Orange Juice	R	Orange Juice	
	(+Peaches-Day 13	RSB)			Coffee w/K	R	Coffee w/K	
							(+Fruit Cocktail-Day 12	
							(++Delete on Day 12	
B	Chicken & Rice Soup	RSB	Corn Chowder	RSB	Lobster Bisque	RSB	Pea Soup	RSB
	Hamburger & White Bread(1)	WP	Turkey & Gravy	WP	Bread Rye (2)		Meatballs w/Sauce	WP
	Pears	IMB	Vanilla Pudding	WP	Ham Spread (Day 7)	WP	Lemon Pudding +	WP
	Instant Breakfast	R	White Bread (1) & Peanut Butter	WP	Cherry Food Bar (2)	IMB	Sugar Cookies (4)	DB
	Cereal Bar	DB	Apricot Food Bar (2)	IMB	Graham Cracker Cubes (6)	DB	Apricots	IMB
	Citrus Beverage w/K	R	Orange Drink W/K	R	Cocoa w/K	R	Orange-Grapefruit Drink w/K	R
					Tuna Spread (Day 11)	WP	(+Pork & Scalloped Potatoes-Day 8 & 12	RSB
C	Cr. Tomato Soup	RSB	Cr. Potato Soup	RSB	Romaine Soup	RSB	Beef & Gravy	WP
	Spaghetti/Meat Sauce	RSB	Frankfurters (4)	WP	Beef Steak	WP	Chicken Stew	RSB
	Peach Ambrosia	RSB	Chocolate Pudding	RSB	Chicken & Rice	RSB	Butterscotch Pudding	RSB
	Brownies (4)	DB	Orange-Grapefruit Drink w/K	R	Pineapple Fruitcake (4)	DB	Chocolate Bar	DB
	Pecans (6)	DB			Pecans (6)	DB	Gingerbread (4)	DB
	Cocoa w/K	R			Grape Drink w/K	R	Citrus Beverage w/K	R

*Meal C only
**Meal A only

3B SKYLAB MEAL

Turkey & Rice Soup	RC
Rye Bread (2)	
Chicken Spread (1/3)	WP
Peaches	WP
Peanuts	CAN
S/L Grapefruit Crystals w/K	SBD

DB = Dry Bite
IMB = Intermediate Moisture Bite
R = Rehydratable
RSB = Rehydratable Spoon Bowl
WP = Wet Pack
RC = Rehydratable Can
SBD = Skylab Beverage Dispenser

TABLE 40

APOLLO 16

PANTRY STOWAGE ITEMS

BEVERAGES	QTY
Cocoa	6
Coffee (B)	16
Instant Breakfast	9
Grapefruit Drink	6
Orange Beverage	6
Orange-Grapefruit Beverage	6
Orange Juice	12
Orange-Pineapple Drink w/K	6

SOUPS/SALADS/MEATS	QTY
Salmon Salad	3
Tuna Salad	3
Shrimp Cocktail	3
Romaine Soup	3
Potato Soup	3
Pea Soup	3
Spaghetti w/Meat Sauce	3
Chicken Stew	3

BREAKFAST ITEMS	
Bacon Squares (8)	6
Spiced Fruit Cereal	3
Cornflakes	3
Scrambled Eggs	6
Grits	3
Peach Ambrosia	3
Sausage Patties	3

SANDWICH SPREADS	
Peanut Butter	3
Jelly	3
Ham Salad	1
Catsup*	7
Mustard*	7

SNACK ITEMS	
Pecans (6)	3
Apricots (IMB) (38.5 g)	6
Peaches (IMB) (39 g)	8
Pears (IMB) (42 g)	6
Apricot Food Bar (1) (26 g)	9
Apple Food Bar (1) (26 g)	9
Lemon Food Bar (1) (26 g)	9
Cherry Food Bar (1) (26 g)	9
Cereal Bar	6
Chocolate Bar	3
Sugar Cookies (4)	3
Graham Crackers (6)	3
Cheese Cracker Cubes (4)	3

ACCESSORIES	
Wet Skin Cleaning Towels	9
Contingency Feeding System	
3 Food Restrainer Pouches	
3 Beverage Packages	
1 Valve Adapter (pontube)	
Germicidal Tablets	
Index Card	

*Stowage locations TBD

TABLE VI

APOLLO 17 CSM 114 MENU Eu ne A. Cernan, CDR

Meal	Day 1*, 5, 9***, 13		Day 2, 6**, 10, 14**		Day 3, 11		Day 4, 12	
A	Bacon Squares (8)	IMB	Spiced Oat Cereal	RSB	Scrambled Eggs	RSB	Sausage Patties	R
	Scrambled Eggs	RSB	Sausage Patties	R	Bacon Squares (8)	IMB	Apricot Cereal	
	Cornflakes	RSB	Mixed Fruit	WP	Peaches	WP	Cubes (4)	DB
	Peaches	RSB	Cinnamon Toast Bread (4)	DB	Pineapple GF Drink	R	Fruit Cocktail	R
	Orange Beverage	R	Instant Breakfast	R	Cocoa w/K	R	Pears	IMB
	Cocoa	R	Coffee w/K	R			Cocoa w/K	R
							Coffee	R
B	Chicken and Rice		Corn Chowder	RSB	Lobster Bisque	RSB	Chicken Soup	RSB
	Soup	RSB	Frankfurters	WP	Peanut Butter	WP	Ham (Ir)	WP
	Meatballs and	WP	Bread, white (2)		Jelly	WP	Cheddar Cheese	
	Sauce		Catsup	WP	Bread, white (1)		Spread	WP
	Fruitcake	WP	Apricots	IMB	Chocolate Bar	IMB	Bread, Rye (1)	
	Lemon Pudding	WP	Orange GF Drink	R	Orange GF Drink w/K	R	Cereal Bar	IMB
	Orange P/A Drink	R					Orange Beverage	R
C	Potato Soup	RSB	Turkey and Gravy	WP	Shrimp Cocktail	RSB	Tomato Soup	RSB
	Beef and Gravy	WP	Pork & Potatoes	RSB	Beef Steak	WP	Hamburger	WP
	Chicken Stew	RSB	Brownies (4)	DB	Butterscotch		Mustard	WP
	Ambrosia, Peach	RSB	Orange Juice	R	Pudding	RSB	Vanilla	
	Gingerbread (4)	DB	Lemonade	R	Peaches	IMB	Pudding	WP
	Citrus Beverage	R			Orange Drink w/K	R	Date Fruitcake	
							(4)	IMB
							Orange P/A	
							Drink w/K	R

* Meal C only
** Meal A only
*** Meals B and C only

DB = Dry Bite
R = Rehydratable
WP = Wet Pack

IMB = Intermediate Moisture Bite
RSB = Rehydratable Spoon Bowl
Ir = Irradiated

TABLE 42

APOLLO 17 - LM 12 MENU, Eugene A. Cernan, CDR

Meal	Day 6		Meal	Day 7		Meal	Day 8		Meal	Day 9	
B	Corn Chowder	RSB	A	Scrambled Eggs	RSB	A	Sausage Patties	R	A	Bacon Squares (8)	IMB
	Frankfurters	WP		Bacon Squares (8)	IMB		Apricot Cereal Cubes (6)	DB		Scrambled Eggs	RSB
	Bread, White (2)			Peaches	IMB		Fruit Cocktail	R		Cornflakes	RSB
	Catsup	WP		Peanut Butter	WP		Pears	IMB		Beef and Gravy	WP
	Apricots	IMB		Jelly	WP		Cereal Bar	IMB		Fruitcake	WP
	Orange GF Drink	R		Bread, White (1)			Cheese Cracker Cube (4)	DB		Peaches	RSB
	Tea	R		Chocolate Bar	IMB		Ham (Ir)	WP		Cocoa	R
	Lemonade	R		Pineapple GF Drink	R		Cocoa	R		Orange Beverage	R
				Orange GF Drink w/K	R		Tea	R		Tea	R
				Cocoa w/K	R		Spiced Oat Cereal	RSB			
				Tea	R		Lemonade	R			
C	Spaghetti & Meat Sauce	RSB	B	Chicken and Rice	RSB	B	Lobster Bisque	RSB			
	Turkey and Gravy	WP		Shrimp Cocktail	RSB		Hamburger	WP			
	Pork and Potatoes	RSB		Beef Steak	WP		Mustard	WP			
	Brownies (4)	DB		Beef Sandwiches (4)	DB		Cheddar Cheese Spread	WP			
	Orange Beverage	R		Butterscotch Pudding	RSB		Bread, Rye (1)				
	Tea	R		Graham Cracker Cube (6)	DB		Date Fruitcake (4)	IMB			
				Orange Drink w/K	R		Orange PA Drink w/K	R			
				Tea	R		Orange Beverage	R			
							Tea	R			

In-Suit Food Bar Assembly	6 ea P/N:	SEB 13100218-301
In-Suit Drinking Device	4 ea P/N:	14-0151-02
Spoon Assembly (2)	1 ea P/N:	14-0144-01
Germicidal Tablets Pouch (42)	1 ea P/N:	14-02166
Germicidal Tablets Pouch (20)	1 ea P/N:	14-

DB = Dry Bite
R = Rehydratable
WP = Wet Pack

IMB = Intermediate Moisture Bite
RSB = Rehydratable Spoon Bowl

TABLE 43

APOLLO 17 CSM 114 MENU, Harrison H. Schmitt, LMP

Meal	Day 1*, 5, 9***, 13		Day 2, 6**, 10, 14**		Day 3, 11		Day 4, 12	
A	Bacon Squares (8)	IMB	Sausage Patties	R	Scrambled Eggs	RSB	Sausage Patties	R
	Scrambled Eggs	RSB	Cinnamon Toast Bread (4)	DB	Bacon Squares (8)	IMB	Grits	RSB
	Cornflakes	RSB	Mixed Fruit	WP	Peaches	WP	Peaches	RSB
	Apricots	IMB	Instant Breakfast	R	Orange P/A Dr. w/K	R	Pears	IMB
	Cocoa	R	Coffee w/K	R	Cocoa	R	Pineapple GF Drink	R
							Coffee w/K	R
B	Chicken & Rice Soup	RSB	Corn Chowder	RSB	Potato Soup	RSB	Chicken Soup	RSB
	Meatballs w/ Sauce	WP	Frankfurters	WP	Peanut Butter	WP	Ham (Ir)	WP
	Fruitcake	WP	Bread, White (2)		Jelly	WP	Cheddar Cheese Spread	WP
	Lemon Pudding	WP	Catsup	WP	Bread, White (1)		Bread, Rye (1)	
	Citrus Beverage	R	Chocolate Pudding	RSB	Cherry Bar (1)	IMB	Cereal Bar	IMB
			Orange GF Drink w/K	R	Orange GF Dr w/K	R	Orange Drink w/K	R
C	Lemonade	R	Turkey and Gravy	WP	Shrimp Cocktail	RSB	Tomato Soup	RSB
	Beef and Gravy	WP	Pork and Potatoes	RSB	Beef Steak	WP	Hamburger	WP
	Chicken Stew	RSB	Carmel Candy	IMB	Butterscotch Pudding	RSB	Mustard	WP
	Ambrosia	RSB	Orange Juice	R	Peaches	IMB	Vanilla Pudding	WP
	Gingerbread (4)	DB			Orange Drink w/K	R	Chocolate Bar	IMB
	Grapefruit Drink w/K	R					Grape Drink w/K	R

* Meal C only
** Meal A only
*** Meals B and C only

DB = Dry Bite IMB = Intermediate Moisture Bite
R = Rehydratable RSB = Rehydratable Spoon Bowl
WP = Wet Pack Ir = Irradiated

TABLE 44

APOLLO 17 - LM 12 MENU, Harrison H. Schmitt, LMP

Meal	Day 6			Day 7			Day 8			Day 9	
B	Corn Chowder	RSB	A	Scrambled Eggs	RSB	A	Sausage Patties	R	A	Bacon Squares (8)	IMB
	Frankfurters	WP		Bacon Squares (8)	IMB		Spiced Oat Cereal	RSB		Scrambled Eggs	RSB
	Bread, White (2)			Peaches	IMB		Peaches	RSB		Cornflakes	RSB
	Catsup	WP		Peanut Butter	WP		Pears	IMB		Apricots	IMB
	Chocolate Pudding	RSB		Jelly	WP		Cereal Bar	IMB		Cocoa	R
	Orange GF Drink	R		Bread, White (1)			Gingerbread	DB		Tea	R
	Tea	R		Orange GF Drink w/K	R		Ham (Ir)	WP		Beef and Gravy	WP
	Lemonade	R		Cocoa w/K	R		Pineapple GF Drink	R		Fruitcake	WP
				Tea	R		Tea	R			
				Fruit Cocktail	R						
C	Turkey and Gravy	WP	B	Chicken & Rice	RSB	B	Potato Soup	RSB			
	Pork and Potatoes	RSB		Shrimp Cocktail	RSB		Hamburger	WP			
	Carmel Candy	IMB		Beef Steak	WP		Mustard	WP			
	Orange Beverage	R		Beef Sandwiches (4)	DB		Cheddar Cheese Spread	WP			
	Tea	R		Butterscotch Pudding	RSB		Bread, Rye (1)				
				Graham Cracker Cube (6)	DB		Chocolate Bar	IMB			
				Orange Drink w/K	R		Banana Pudding	RSB			
				Orange P/A Drink	R		Orange Drink w/K	R			
				Tea	R		Grape Drink w/K	R			
							Tea	R			

TABLE 45

APOLLO 17 CSM 114 MENU, Ronald E. Evans, CMP

Meal	Day 1*, 5, 9, 13		Day 2, 6, 10, 14**		Day 3, 7, 11		Day 4, 8, 12	
A	Bacon Squares (8)	IMB	Spiced Oat Cereal	RSB	Scrambled Eggs	RSB	Sausage	R
	Scrambled Eggs	RSB	Sausage Patties	R	Bacon Squares (8)	IMB	Grits	RSB
	Cornflakes	RSB	Mixed Fruit	WP	Peaches	WP	Fruit Cocktail	R
	Apricots	IMB	Instant Breakfast	R	Cinnamon Toast Bread (4)	DB	Orange Beverage	R
	Orange Juice	R	Coffee w/K	R	Orange Juice	R	Coffee w/K	R
					Cocoa w/K	R		
B	Chicken & Rice Soup	RSB	Frankfurters	WP	Lobster Bisque	RSB	Ham (Ir)	WP
	Meatballs w/Sauce	WP	Bread, White (2)		Peanut Butter	WP	Cheddar Cheese Spread	WP
	Fruitcake	WP	Catsup	WP	Jelly	WP	Bread, Rye (1)	
	Butterscotch Pudding	WP	Pears	IMB	Bread, White (1)		Peaches	RSB
	Orange PA Drink	R	Chocolate Pudding	RSB	Cherry Bar (1)	IMB	Cereal Bar	IMB
			Grape Drink w/K	R	Citrus Beverage w/K	R	Orange PA Drink w/K	R
C	Potato Soup	RSB	Corn Chowder	RSB	Shrimp Cocktail	RSB	Tomato Soup	RSB
	Beef and Gravy	WP	Turkey & Gravy	WP	Beef Steak	WP	Hamburger	WP
	Chicken Stew	RSB	Chocolate Bar	IMB	Butterscotch Pudding	RSB	Mustard	WP
	Ambrosia	RSB	Orange Beverage	R	Orange Drink w/K	R	Vanilla Pudding	WP
	Brownies (4)	DB					Sugar Cookies (4)	DB
	Orange GF Drink	R					Carmel Candy	IMB
							Grape Drink w/K	R

* Meal C only
** Meal A only

DB = Dry Bite
R = Rehydratable
WP = Wet Pack
IMB = Intermediate Moisture Bite
RSB = Rehydratable Spoon Bowl
Ir = Irradiated

TABLE 46

APOLLO 17 PANTRY STOWAGE ITEMS

BEVERAGES	QTY
Coffee (B)	20
Tea	20
Grape Drink	10
Grape Punch	10

ACCESSORIES	QTY
Contingency Feeding System P/N: SEB 39104484-301	1
Germicidal Tablets (42) P/N: 14-02166	3
Index Card	1
S/L Beverage Dispenser (empty)	3
Contingency Beverages (For Contingency Use Only)	30
15 Instant Breakfast	
5 Orange Drink	
5 Pineapple Orange Drink	
5 Lemonade	

SNACK ITEMS	
Bacon Squares (4)	9
Apricot Cereal Cubes (4)	6
Brownies (4)	3
Gingerbread (4)	3
Graham Crackers (4)	6
Jellied Candy	6
Peach Ambrosia	3
Pecans (6)	6
Fruitcake (WP)	3
Sugar Cookies (4)	6
Apricots (IMB)	3
Peaches (IMB)	3
Pears (IMB)	3
Chocolate Bar (IMB)	3
Tuna Salad Spread (WP) (Small Cans)	2
Catsup (WP)	3
Salt Packets	6

TABLE 47. AVERAGE DAILY IN-FLIGHT NUTRIENT INTAKES DURING APOLLO FLIGHTS

	Days	Calories	N_2 g	Protein g	Fat g	CHO g	Crude Fiber g	Ash g	Ca mg	P mg	Fe mg	Na mg	K mg	Mg mg
Apollo 7	10													
Schirra, CDR		1970	12.96	81	72	259		16	644	1060	8	3810	1879	192
Cunningham, LMP		1800	11.84	74	56	268		14	925	841	7	3480	1336	141
Eisele, CMP		2140	15.36	96	78	280		18	938	1125	9	4000	1958	185
Apollo 8	6													
Borman, CDR		1480	9.44	59	39	231	2.1	11	427	847	5	3170	1229	113
Anders, LMP		1340	8.32	52	33	217	1.8	10	366	760	5	2730	986	97
Lovell, CMP		1690	12.80	80	49	240	2.4	15	479	983	7	3980	1571	145
Apollo 9	10													
McDivitt, CDR		1920	13.76	86	60	280	2.9	15	562	1146	7	4000	1677	157
Schweickart, LMP		1640	10.56	66	47	252	2.5	13	494	892	6	3410	1386	129
Scott, CMP		1720	12.48	78	53	240	2.5	14	489	1073	6	3770	1708	146
Apollo 10	8													
Stafford, CDR		1350	9.28	58	34	213		3	836	814	6	2970	1463	107
Cernan, LMP		1250	7.84	49	30	208		3	854	701	5	2670	1182	96
Young, CMP		1260	7.36	46	30	213		3	808	746	5	2290	1376	104
Apollo 11	8													
Armstrong, CDR		2040	12.64	79	65	290		17	1036	1050	8	2770	1751	138
Aldrin, LMP		2280	15.04	94	73	322		19	1114	1225	9	3220	2061	166
Collins, CMP		1640	11.36	71	54	224		14	851	901	7	2060	1441	119
Apollo 12	10													
Conrad, CDR		1750	11.20	70	50	263	4.6	16	1095	1090	9	3580	1835	119
Bean, LMP		1690	9.12	57	42	280	3.3	15	1291	965	7	3290	1484	108
Gordon, CMP		1670	10.40	65	49	249	3.9	15	1022	1028	8	3240	1685	117

TABLE 47. AVERAGE DAILY IN-FLIGHT NUTRIENT INTAKES DURING APOLLO FLIGHTS (CONTINUED)

	Days	Calories	N_2 g	Protein g	Fat g	CHO g	Crude Fiber g	Ash g	Ca mg	P mg	Fe mg	Na mg	K mg	Mg mg
Apollo 13	7													
Lovell, CDR		1580	9.44	59	50	239	4.6	15	870	780	8	3630	2036	107
Haise, LMP		1520	9.12	57	49	228	4.5	15	786	716	8	3350	1964	102
Swigert, CMP		1540	9.12	57	47	235	4.5	15	871	720	8	3480	1942	98
Apollo 14	8													
Shepard, CDR		2310	14.40	90	76	309	4.0	20	802	1308	11	4870	2485	181
Mitchell, LMP		2330	12.96	81	89	319	4.3	20	843	1304	11	4750	2576	192
Roosa, CMP		1720	12.64	79	61	230	3.2	17	809	1109	8	3780	2147	149
Apollo 15	11													
Scott, CDR		2093	20.16	126	115	356	8.2	26	810	1914	16	6529	3554	270
Irwin, LMP		2572	17.44	109	94	334	7.9	21	790	1636	13	5131	2923	219
Worden, CMP		2492	16.00	100	89	421	7.2	21	748	1624	12	5274	2720	210
Apollo 16	11													
Young, CDR		1610	14.08	88	73	319	6.2	20	821	1748	14	4077	4456	238
Duke, LMP		1632	12.64	79	60	295	5.3	19	618	1419	13	3568	4170	212
Mattingly, CMP		1226	8.32	52	50	203	3.1	12	477	1050	8	2719	3191	159
Apollo 17	12													
Cernan, CDR		1902	14.08	88	68	248	3.9	19	674	1440	14	6004	3009	189
Schmitt, LMP		2148	13.92	87	87	293	5.3	19	705	1525	15	3825	3451	211
Evans, CMP		2402	15.68	98	104	314	5.3	22	727	1640	16	4590	3826	242

TABLE 48

PRODUCTION GUIDES FOR THE APOLLO FOOD SYSTEM

T.I. No.	Title
001	Chicken and Rice Soup
002	Instant Orange Juice
003	Mobile Quarantine Facility Food Procurement
003-A	Apollo Preflight and Postflight Food Procurement
004	Frozen Food for Lunar Receiving Lab
005	Bread
006	Margarine
007	Ice Cream
008	Precooked Sliced Meat and Poultry Products
009	Dried Apricots, Peaches and Pears
010	Frozen Meals for In-flight Food System
011	Pecans
012	Canned Peaches and Mixed Fruit
013	Beef Jerky
014	Pudding
015	Chocolate Candy Bars
016	Fruit Bars
016 Attachment #1	Edible Amylomaize Starch Packaging Film
017	Freeze-Dried Soups
018	Chocolate Flavored Space Food Bar
020	Peanut Butter Flavored Chocolate Bar
021	Instant Grits Product
025	Instant Tea

TABLE 49

COMPARISON OF CALORIC EXPENDITURES AND INTAKES AND WEIGHT LOSS

APOLLO 7 THROUGH 12

Apollo Flight	Mean CO_2 Expenditure BTU/hr/man	Mean Daily Caloric Expenditure	Duration of Flight (Days)	Pilot Identification Code	Mean Daily Caloric Intake	Total Weight Loss (pounds)	% Loss Body Weight	Body Weight Launch Day (pounds)
7	455	2752	10	CDR	1966	4.25	2.2	194
				LMP	1804	6.50	4.2	156
				CMP	2144	10.00	6.4	157
8	388	2347	6	CDR	1477	8.50	5.0	169
				LMP	1339	4.00	2.8	142
				CMP	1688	8.00	4.7	172
9	368	2226	10	CDR	1924	5.50	3.5	159
				LMP	1639	6.00	3.8	159
				CMP	1715	5.50	3.1	178
10	339	2050	8	CDR	1346	2.50	1.5	171
				LMP	1246	10.00	5.8	173
				CMP	1265	5.50	3.3	165
11	413	2498	8	CDR	2040	8.00	4.7	172
				LMP	2278	1.00	0.6	167
				CMP	1645	7.00	4.2	166
12	375	2268	10	CDR	1751	4.25	2.8	149
				LMP	1669	12.50	8.2	152
				CMP	1689	7.25	4.7	155

APPENDIX A

APOLLO 14 FOOD SYSTEM

Apollo 14 Food System

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The program for improving foods for use during space flights consists of introducing new foods and food-handling techniques on each successive manned space flight. Because of this continuing improvement program, the Apollo 14 food system was the most advanced and sophisticated food system to be used in the U.S. space program. The food system used during the Apollo 14 mission and recent space-food-system advances are described and discussed in regard to their usefulness for future manned space flights.

THE MOST ADVANCED food system yet developed for space flight was used during the Apollo 14 lunar-landing mission. This system provided balanced nutrition for the astronauts during all phases of the epic accomplishments of the mission. Unique constraints were imposed on the food system by the variety of environments and operational conditions that were encountered by the crewmen during this flight. To satisfy all conditions, a wide variety of novel foods, food-production methods, packages, and food-preparation modes were used.

The long-standing objective for a food system for manned space flight has been to provide the crewmembers with appetizing, safe, nutritious, and convenient food that is light in weight, small in volume, and compatible with the mission.[12,13] Based on results of laboratory research and of simulated null-gravity studies of foods during Keplerian trajectory flights in C-135 aircraft, candidate foods and packages that appear to have the desired characteristics for use during space flight are selected. Then, candidate foods and packages are used on an Apollo flight. As a result, a wide variety of foods and dispensing techniques has been added to the inventory of efficient and acceptable means for dietary support of man in space. On each successive flight in the U.S. manned space program, food-system improvements have been introduced so that a logical sequence of progressive development has occurred from the earliest concepts[10,14] to the advanced food system of today.

The Apollo 14 food system incorporated many of the advances in research and development that have been accomplished in space-flight food systems during the past decade. These advances are indicative of the potential for future improvements. In this report, the Apollo 14 food system is described, and some implications for future food systems are discussed.

RESULTS AND DISCUSSION

The use of Apollo 14 food system began shortly after launch and continued during all phases of the mission. The primary mission phases were the times the crewmembers occupied the command module (CM) in flight, the lunar module (LM) on the lunar surface, the Mobile Quarantine Facility (MQF) during transport from the recovery site in the South Pacific Ocean, and the Lunar Receiving Laboratory (LRL) at the Manned Spacecraft Center (MSC) in Houston, Texas. For each of these environments, a different set of constraints and requirements was imposed on the food system.

Before launch each prime and backup crew member conscientiously evaluated available flight foods and selected preferred food items. These foods subsequently were assembled into nutritionally balanced menus designed to provide approximately 8800 kilojoules (2105 kilocalories) and 100 grams of protein per man per day. The crew members were briefed on the spacecraft stowage, food-preparation procedures, and methods of waste disposal. After donning his suit and before departing for the launch pad, each crewman was supplied with a specially prepared frozen sandwich, a package of bacon squares, and a rehydratable beverage. These foods were overwrapped in fluorohydrocarbon material and placed in a pocket of the space suit for consumption ad libitum during the first eight hours after launch. The sandwiches were prepared in the MSC Food and Nutrition Laboratory 72 hours before launch; quality control inspection assured that the sandwiches met all applicable spacecraft and food-system requirements. If, for some reason, microbiological safety standards had been violated, the frozen sandwiches would have been withdrawn and the crew would have chosen replacement items from the nominal mission foods.

During flight days 1 to 5, the physical appearance of foods in the CM contrasted sharply to conventional foods. The foods provided for each crewmember for days 1 to 5 are listed in Tables I to III. Manufacturing specifications for many of these foods have been reported previously.[5] New foods included for the Apollo 14 mission that had never been consumed in space were lobster bisque and peach ambrosia, both rehydratable; beef jerky in ready-to-eat bite-size pieces; and diced peaches, mixed fruit, and pudding, which are thermostabilized. The thermostabilized items were packaged in 201 x 208 aluminum cans with easy-open full-panel

TABLE I. APOLLO 14 MENUS FOR THE COMMANDER, DAYS 1 TO 5

Day	Breakfast		Lunch		Dinner		Calories Per Day
	Food Item	Type[a]	Food Item	Type[a]	Food Item	Type[a]	
[b]1 and 5	Peaches	RSB	Chicken and Rice	RSB	Cream of Tomato Soup	RSB	1748
	Scrambled Eggs	RSB	Applesauce	RSB	Spaghetti and Meat Sauce	RSB	
	Bacon Squares (8)	IM	Chocolate Bar	IM	Peach Ambrosia	RSB	
	Grapefruit Drink	RD	Orange-Grapefruit Drink	RD	Cheese Cracker Cubes (4)	D	
	Coffee, Black	RD			Grape Drink	RD	
2	Fruit Cocktail	RSB	Turkey and Gravy	T	Cream of Chicken Soup	RSB	2272
	Sausage Patties	RSB	Cranberry-Orange Sauce	RSB	Frankfurters	T	
	Spiced Fruit Cereal	RSB	Pineapple Fruitcake	IM	Banana Pudding	RSB	
	Orange Drink	RD	Grape Punch	RD	Brownies (4)	IM	
	Coffee, Black	RD			Pineapple-Orange Drink	RD	
3	Peaches	T	Pea Soup	RSB	Lobster Bisque	RSB	2157
	Scrambled Eggs	RSB	Bread Slices (2)[c]	NS	Beef Stew	RSB	
	Bacon Squares (8)	IM	Sandwich Spread[d]	T	Beef Sandwiches (4)	D	
	Grape Drink	RD	Butterscotch Pudding	RSB	Caramel Candy	IM	
	Coffee, Black	RD	Grapefruit Drink	RD	Orange-Grapefruit Drink	RD	
4	Mixed Fruit	T	Chicken and Rice Soup	RSB	Beef and Gravy	T	2098
	Canadian Bacon and Applesauce	RSB	Meatballs with Sauce	T	Chicken and Vegetables	RSB	
	Cornflakes	RSB	Lemon Pudding	T	Chocolate Pudding	RSB	
	Pineapple-Grapefruit Drink	RD	Graham Cracker Cubes (4)	D	Sugar Cookie Cubes (4)	D	
	Coffee, Black	RD	Grape Punch	RD	Grapefruit Drink	RD	

[a]Definitions: RSB = rehydratable, spoon bowl; RD = rehydratable drink; IM = intermediate moisture; D = dehydrated; T = thermostabilized; NS = natural state.
[b]Dinner was eaten on day 1; breakfast was eaten on day 5.
[c]Cheese, rye, or white.
[d]Chicken, ham, tuna salad, cheddar cheese spread, peanut butter, jelly.

TABLE II. APOLLO MENUS FOR THE LUNAR MODULE PILOT, DAYS 1 TO 5

Day	Breakfast		Lunch		Dinner		Calories Per Day
	Food Item	Type[a]	Food Item	Type[a]	Food Item	Type[a]	
[b]1 and 5	Peaches	RSB	Beef Pot Roast	RSB	Cream of Tomato Soup	RSB	1835
	Scrambled Eggs	RSB	Applesauce	RSB	Pork and Escalloped Potatoes	RSB	
	Bacon Squares (8)	IM	Jellied Fruit Candy	IM	Peach Ambrosia	RSB	
	Grapefruit Drink	RD	Orange-Grapefruit Drink	RD	Cheese Cracker Cubes (4)	D	
	Coffee, Black	RD			Grape Drink	RD	
2	Fruit Cocktail	RSB	Beef and Gravy	T	Cream of Chicken Soup	RSB	2139
	Apricot Cereal Cubes (4)	D	Cranberry-Orange Sauce	RSB	Frankfurters	T	
	Spiced Fruit Cereal	RSB	Pineapple Fruitcake (4)	IM	Banana Pudding	RSB	
	Orange Drink	RD	Grape Punch	RD	Brownies (4)	IM	
	Coffee, Black	RD			Pineapple-Grapefruit Drink	RD	
3	Peaches	T	Pea Soup	RSB	Lobster Bisque	RSB	2268
	Scrambled Eggs	RSB	Bread Slices (2)[c]	NS	Beef Stew	RSB	
	Bacon Squares (8)	IM	Sandwich Spread[d]	T	Beef Sandwiches (4)	D	
	Grape Drink	RD	Butterscotch Pudding	RSB	Apricots	IM	
	Coffee, Black	RD	Grapefruit Drink	RD	Caramel Candy	IM	
					Cocoa	RD	
4	Mixed Fruit	T	Corn Chowder	RSB	Beef and Gravy	T	2365
	Canadian Bacon and Applesauce	RSB	Meatballs with Sauce	T	Potato Soup	RSB	
	Cornflakes	RSB	Vanilla Pudding	T	Chocolate Pudding	RSB	
	Pineapple-Grapefruit Drink	RD	Chocolate Bar	IM	Sugar Cookie Cubes (4)	D	
	Coffee, Black	RD	Grape Punch	RD	Pineapple-Grapefruit Drink	RD	

[a]Definitions: RSB = rehydratable, spoon bowl; RD = rehydratable drink; IM = intermediate moisture; D = dehydrated; T = thermostabilized; NS = natural state.
[b]Dinner was eaten on day 1; breakfast was eaten on day 5.
[c]Cheese, rye, or white.
[d]Chicken, ham, tuna salad, cheddar cheese spread, peanut butter, jelly.

pull-out lids. The foods available for the commander (CDR) and the lunar module pilot (LMP) in the LM are presented in Table IV. During the lunar-surface-operation phase, the command module pilot (CMP) continued his nominal menu with selection options from the pantry. The foods for the transearth flight (days 6 to 10) are given in Table V.

The average weight and storage volume per man per day for the Apollo 14 food and package were 1,125.9 grams (2.48 pounds) and 3,083 cubic centimeters (188 cubic inches), respectively. Comparable weights and volumes of food for the Apollo 7 and 10 missions were 871.7 grams (1.92 pounds) and 1,026.2 grams (2.26 pounds) and 2,558 cubic centimeters (156 cubic inches) and 2,919 cubic centimeters (178 cubic inches), respectively. Optimum utilization of weight and volume was attained during the Apollo 7 mission by using a high proportion of rehydratable food. Trade-off studies always will favor a predominance of rehydratable food in the food system as long as water is available from fuel cells and as long as weight savings for the food can be translated into payload.

The system-design experience from the Apollo Program is being used for the development of advanced-mission food-system weight-and-volume design criteria. For example, the weight and volume per man per day are relatively high in the Skylab Program food system, which is designed for prolonged flight periods of as many as 56 days. The food weight and volume figures inches) per man per day are specified. Criteria for excellent vehicle-payload advantage and for maintenance predicted for Skylab, which is scheduled for earth-orbital flight early in 1973, are 1,905.1 grams (4.2 pounds) and 5,629.0 cubic centimeters (343.5 cubic inches) per man per day. This is more than twice the weight and volume of the Apollo 7 food system. In contrast, the food system for the space shuttle, which is planned for launch in 1975, is being designed for maximum flights of 5 days, and weights and volumes of 907.2 grams (2.0 pounds) and 4,096.8 cubic centimeters (250 cubic of the highest food quality by maximum utilization of freeze-dried foods are included in the design specifications for the space shuttle food system.

Most of the foods used during the null-gravity phases of the Apollo 14 mission were stored, rehydrated, and served in spoon-bowl packages (Figure 1). Considerable research and development went into the successful design of this flexible spoon-bowl package, which allows food consumption during weightlessness in a more conventional manner. The astronauts rehydrate the food by injecting hot or cold water, as appropriate, into the package by using a water gun inserted through the one-way spring-loaded water valve. Foods intended for consumption while hot are rehydrated with hot water (approximately 66°C), and cold foods are rehydrated with cool water (approximately 7°C). The water is derived as a byproduct of electrical-power generation in the spacecraft fuel cells. After the food is rehydrated with

TABLE III. APOLLO 14 MENUS FOR THE COMMAND MODULE PILOT, DAYS 1 TO 5

Day	Breakfast		Lunch		Dinner		Calories Per Day
	Food Item	Type[a]	Food Item	Type[a]	Food Item	Type[a]	
[b]1 and 5	Peaches	RSB	Pea Soup	RSB	Cream of Tomato Soup	RSB	2006
	Scrambled Eggs	RSB	Chicken Salad	RSB	Tuna Salad	RSB	
	Bacon Squares (8)	IM	Turkey Bites (4)	D	Spaghetti and Meat Sauce	RSB	
	Orange Drink	RD	Orange-Grapefruit Drink	RD	Cheese Cracker Cubes (4)	D	
	Cocoa	RD			Orange Drink	RD	
2	Fruit Cocktail	RSB	Corn Chowder	RSB	Potato Soup	RSB	2128
	Cinnamon Toasted Bread Cubes (4)	D	Turkey and Gravy	T	Meatballs with Sauce	T	
	Pork and Scalloped Potatoes	RSB	Cheese Sandwiches (4)	D	Chicken and Rice	RSB	
	Orange-Grapefruit Drink	RD	Pineapple-Orange Drink	RD	Peanut Cubes (4)	D	
	Cocoa	RD			Pineapple-Grapefruit Drink	RD	
3	Peaches	T	Pea Soup	RSB	Lobster Bisque	RSB	2013
	Scrambled Eggs	RSB	Bread Slices (2)[c]	NS	Beef Stew	RSB	
	Bacon Squares (8)	IM	Sandwich Spread[d]	T	Potato Salad	RSB	
	Pineapple-Orange Drink	RD	Creamed Chicken Bites (6)	D	Beef Sandwiches (4)	D	
	Cocoa	RD	Orange Drink	RD	Orange-Grapefruit Drink	RD	
4	Mixed Fruit	T	Chicken and Rice Soup	RSB	Beef and Gravy	T	2138
	Canadian Bacon and Applesauce	RSB	Meatballs with Sauce	T	Shrimp Cocktail	RSB	
	Cornflakes	RSB	Chicken Sandwiches (6)	D	Chicken Stew	RSB	
	Orange-Grapefruit Drink	RD	Vanilla Pudding	T	Sugar Cookie Cubes (4)	D	
	Cocoa	RD	Pineapple-Grapefruit Drink	RD	Cocoa	RD	

[a]Definitions: RSB = rehydratable, spoon bowl; RD = rehydratable drink; IM = intermediate moisture; D = dehydrated; T = thermostabilized; NS = natural state.
[b]Dinner was eaten on day 1.
[c]Cheese, rye, or white.
[d]Chicken, ham, tuna salad, cheddar cheese spread, peanut butter, jelly.

TABLE IV. FOODS AVAILABLE ON BOARD THE LM DURING LUNAR STAY[a]

Day	Meal	Food Item	Type[b]	Per Meal Calories
1	Lunch	Cream of Tomato Soup	RSB	906
		Bread Slice	NS	
		Ham Salad Sandwich Spread	T	
		Caramel Candy	IM	
		Pineapple-Grapefruit Drink	RD	
		Grapefruit Drink	RD	
	Supper	Beef and Gravy	T	875
		Cheese Cracker Cubes (4)	D	
		Apricots	IM	
		Butterscotch Pudding	RSB	
		Orange-Grapefruit Drink	RD	
		Grape Punch	RD	
2	Breakfast	Peaches	RSB	668
		Bacon Squares (8)	IM	
		Sugar Coated Cornflakes	RSB	
		Cocoa	RD	
		Orange-Pineapple Drink	RD	
	Lunch	Lobster Bisque	RSB	880
		Meatballs with Sauce	T	
		Chocolate Bar	IM	
		Pineapple Fruitcake	IM	
		Grapefruit Drink	RD	

[a]Two and two-thirds man days (4 meals per crewmember).
[b]Definitions: RSB = rehydratable, spoon bowl; RD = rehydratable drink; IM = intermediate moisture; D = dehydrated; T = thermostabilized; NS = natural state.

a specified amount of water, the package is opened by cutting below the final heat seal with scissors. The contents are eaten by using a conventional stainless-steel spoon.

Although dramatic progress has been made in the design of the packages for rehydratable solid foods, little progress has been made in the design of packages for rehydratable liquid foods. The propensity to flow exhibited by bulk liquids in null gravity makes liquid management a distinctly different problem than management of solid and semisolid foods. The rehydratable-drink packages currently used for the Apollo missions are shown in Figure 2. An intensive development program is underway to modify the drink packages to make them more convenient for the crewmembers to handle during preparation and consumption. Testing of some of the new drink packages will begin during the Apollo 15 mission.

A typical package used for the intermediate moisture (IM) foods and for the dehydrated ready-to-eat bite-size foods is shown in Figure 3. The IM foods used during the Apollo 14 mission were those for which water activity was controlled to assure retardation of chemical and microbiological deterioration while maintaining acceptable texture at the time the foods were consumed.

TABLE V. APOLLO 14 CM PANTRY STOWAGE FOR DAYS 6 TO 10

Food Item	Type[a]	Quantity
Beverages:		
Cocoa	RD	6
Coffee	RD	16
Grape Drink	RD	2
Grapefruit Drink	RD	6
Grape Punch	RD	2
Orange-Grapefruit Drink	RD	6
Orange Juice	RD	20
Pineapple-Grapefruit Drink	RD	6
Pineapple-Orange Drink	RD	6
Total		70
Breakfast items:		
Bacon Squares (8)	IM	12
Cinnamon Toasted Bread Cubes (4)	D	3
Canadian Bacon and Applesauce	RSB	3
Cornflakes	RSB	3
Fruit Cocktail	RSB	3
Sausage Patties	RSB	2
Scrambled Eggs	RSB	6
Peaches	RSB	3
Spiced Fruit Cereal	RSB	3
Apricot	IM	3
Peaches	IM	3
Total		44
Cubes and Candy:		
Brownies (4)	IM	2
Caramel Candy	IM	2
Chocolate Bar	IM	2
Creamed Chicken Bites (6)	D	3
Cheese Cracker	D	6
Cheese Sandwiches (4)	D	3
Beef Sandwiches (4)	D	3
Jellied Fruit Candy	IM	2
Beef Jerky	IM	3
Peanut Cubes (4)	NS	2
Pecans (6)	IM	3
Pineapple Fruitcake	IM	2
Sugar Cookies (4)	D	3
Turkey Bites (4)	D	3
Total		39
Desserts:		
Applesauce	RSB	2
Banana Pudding	RSB	2
Butterscotch Pudding	RSB	2
Chocolate Pudding	RSB	2
Cranberry-Orange Sauce	RSB	3
Peach Ambrosia	RSB	4
Total		15
Salads and Soups:		
Chicken and Rice Soup	RSB	2
Lobster Bisque	RSB	3
Pea Soup	RSB	3
Potato Soup	RSB	3
Shrimp Cocktail	RSB	2
Tomato Soup	RSB	3
Tuna Salad	RSB	2
Total		18
Sandwich Spreads and Bread:		
Bread (Slice)	NS	6
Catsup	NS	3
Cheddar Cheese (2 oz)	NS	3
Chicken Salad (8 oz)	T	1
Ham Salad (8 oz)	T	1
Jelly	NS	3
Mustard	NS	3
Peanut Butter	NS	3
Total		23
Meats:		
Beef Pot Roast	RSB	3
Beef and Vegetables	RSB	3
Beef Stew	RSB	3
Chicken and Rice	RSB	2
Chicken and Vegetables	RSB	2
Chicken Stew	RSB	2
Pork and Scalloped Potatoes	RSB	2
Spaghetti, Meat Sauce	RSB	3
Beef and Gravy	T	4
Frankfurters	T	2
Meatballs, Sauce	T	4
Turkey and Gravy	T	2
Total		32

[a]Definitions: RSB = rehydratable, spoon bowl; RD = rehydratable drink; IM = intermediate moisture; D = dehydrated; T = thermostabilized; NS = natural state.

These IM foods characteristically are in equilibrium and have water activities of 0.2 to 0.75 on a scale for which water activity is expressed as the ratio of partial pressure of water in the food to the vapor pressure of pure water at the given temperature. The IM foods are highly acceptable, nutritious, safe, and very easy to eat. No preparation for eating the IM foods is required other than removal of the food from the package. Additional IM foods are under development for future flights. The most popular IM items in the food-system inventory include jellied fruit candy, pecans, peaches, pears, apricots, fruit cakes, bacon squares, nutrient-defined caramel-flavored candy sticks, and nutritionally complete snacks.

An excellent menu variety was provided by including dehydrated ready-to-eat foods for the Apollo 14 mission. In addition, the dehydrated foods, like the IM foods, were convenient to eat during periods in which the number of required mission activities was increased. Historically, the bite-size dehydrated foods are the oldest items in the space-flight food systems. These foods and tubes of pureed fruit were the basic types of food used during the Mercury space flights. The most acceptable and nutritious of these early food types have been retained for use in contemporary and future space-flight food systems.

Thermostabilized foods are the newest food type to be used in the space program. These foods open the potential for the use of a much wider variety of foods during space flights. Flexible or rigid packages are used. The older package form is the flexible laminate of plastic and aluminum foil that is opened by cutting with scissors at either end and from which food is consumed by using a conventional spoon. This type of package is now in use for commercial products.[1,7] A more recent development in thermostabilized-food packaging for manned space flight is the use of rigid aluminum cans with full-panel pull-out lids. This type of can was used in space for the first time during the Apollo 10 flight in May 1969. The package proved to be so successful that its use in the Apollo food system was expanded to include virtually all categories of thermostabilized foods commercially available in aluminum cans fitted with full-panel pull-out lids. The type of aluminum can used for the Apollo 14 mission is pictured in Figure 4.

Although thermostabilized food in this type of pack-

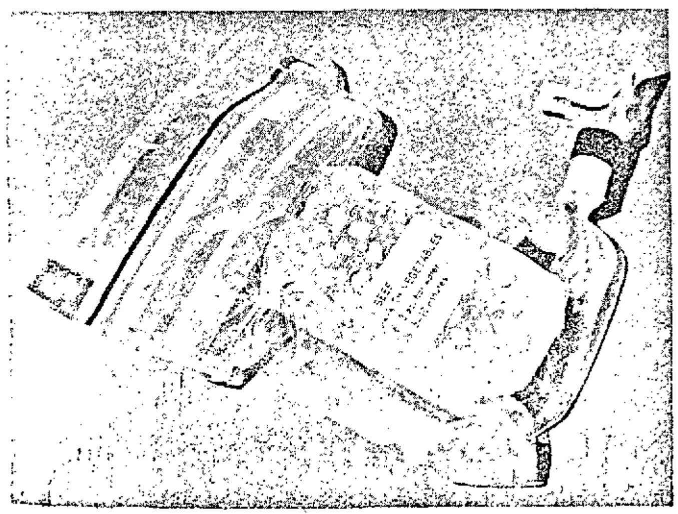

Fig. 1. The Apollo spoon-bowl packet used for rehydratable foods. The food is rehydrated by inserting water through the spring-loaded valve by means of a water gun. Rehydrated food is consumed by using a spoon dipped through the top, which is cut open with scissors.

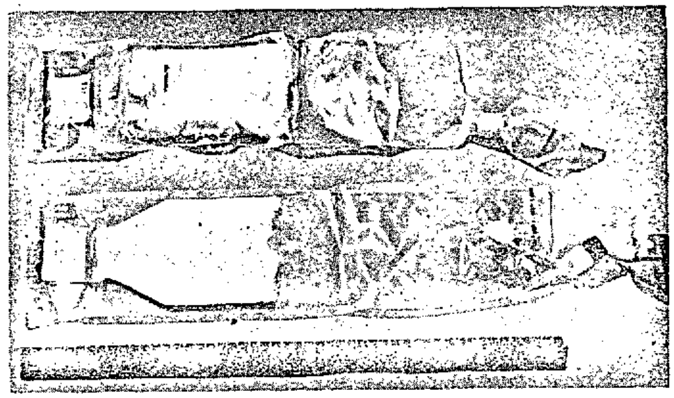

Fig. 2. Apollo-type rehydratable-beverage packages.

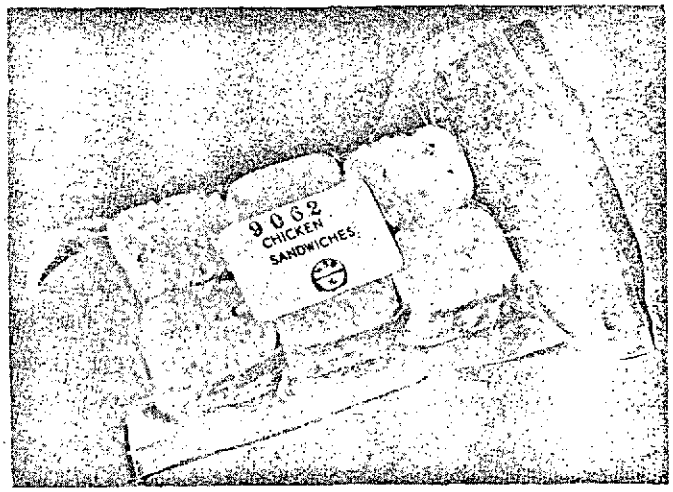

Fig. 3. Apollo 14 package used for intermediate moisture and dehydrated food that is ready to eat.

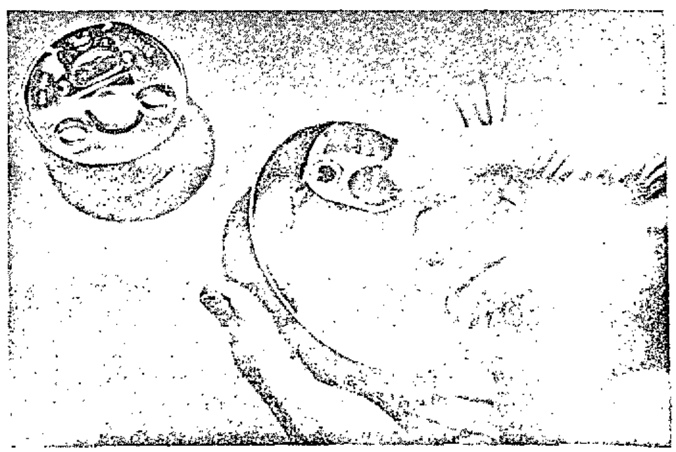

Fig. 4. Apollo 14 food package (aluminum can) with a full-panel pull-out lid.

age readily fulfills the objectives that space food should be appetizing, safe, nutritious, and convenient to eat, it is costly from a weight and volume standpoint in spacecraft systems that have inflight water generation or recovery. Plans are underway for more extensive use of this type of package in the Skylab spacecraft.

During the return flight from the lunar surface, the Apollo 14 astronauts were free to select any of the foods that were stowed in a pantry configuration (Table V). This food selection provided additional information concerning the advantages and problems that are associated with inflight ad libitum or cafeteria-type selection of foods. The principal advantage is assumed to be that the crew member is allowed to select his menu in real time based on appetite and physiological need. The chief problem is that considerable time can be expended in surveying and locating the various food items to assemble the meal. Information derived from the free-choice food-selection phase is expected to be of particular value in determining the stowage configuration of food systems for space flights of longer duration.

One of the unique items in the Apollo 14 pantry was bread baked from irradiated flour.[9] This bread was used for inflight sandwich preparation. Sandwich spreads were thermostabilized by processing in a hyperbaric chamber to reduce time and temperature requirements and to preserve texture. Five-ounce servings were packaged in aluminum cans with full-panel pull-out lids. Inflight sandwich preparation was accomplished without difficulty, and the opportunity to make sandwiches was enjoyed by the crew.

After splashdown and recovery, the astronauts were confined for approximately three days in the MQF during their transport to the MSC LRL in Houston, Texas, by means of the recovery aircraft carrier and a C-141 aircraft. Meals in the MQF consisted primarily of precooked frozen food that required no preparation other than heating in the MQF microwave oven. The Apollo 14 MQF menus are given in Table VI.

During the quarantine period in the LRL, a variety of fresh, frozen, and dry foods and precooked frozen meals was available for the astronauts and the quarantined LRL support staff. The food system was adaptable to variations in the number of persons to be served. Also, the variety of available foods allowed for accommodation and adjustment of the different eating habits, food preferences, and caloric requirements of all quarantined personnel. The LRL food program is now being used as the point of departure for the design of the alert crew food system for the space shuttle program. This program will require strict control of food quality and safety analogous to the controls imposed on the Apollo 14 foods.

Quality control and safety of the Apollo 14 food were attained by in-process inspection at all points of production. End-item examinations included organoleptic tests by trained personnel, analysis of head space for oxygen control, a rehydratability test (where appropriate), analysis of the integrity of the package heat seal, and microbiological examinations. These safety standards are under revision to consider the long-term-storage effects that result principally from oxidative and nonenzymatic browning changes and the recently exacerbated problems of intentional and unintentional additives. These advanced safety standards can have significant public-health implications.[6] Improved quality control and safety standards will be applicable especially to space flights for which foods are stored for longer durations.

In general, the comments by the crew members concerning the quality of the inflight foods and the food system were favorable. One crew member reported a preference for the inflight foods rather than the precooked frozen foods provided in the MQF. Of particular interest were the crew members' comments concerning the wide variety of thermostabilized foods packaged in the aluminum cans with full-panel pull-out lids. The crewmen reported that the lids were removed carefully

TABLE VI. APOLLO 14 MQF FOOD[a]

DAY 1	Day 2	Day 3	Day 4	Day 5
		Breakfast		
Crepes Georgia Cheese Omelette Crisp Bacon Strips Breakfast Roll Jelly	Crepes Normandie Link Sausage Pancakes Maple Syrup	Crepes Diane Cheese Omelette Crisp Bacon Strips Breakfast Roll Jelly	Crepes Georgia Plain Omelette Breakfast Ham Breakfast Roll Jelly	Crepes Normandie French Toast Crisp Bacon Strips Maple Syrup
		Lunch		
Roast Beef Sandwich Corn Relish Mixed Fruit Compote Vanilla Ice Cream Assorted Cookies	Beef Stew Dinner Roll Plums	Spaghetti with Meat Sauce Green Beans Amandine Dinner Roll Vanilla Ice Cream Oatmeal-Raisin Cookies	Roast Beef au jus Duchess Potatoes Glazed Carrots Dinner Roll Fudge Brownies	Braised Beef Tips Tiny Whole Potatoes with Green Peas Dinner Roll Vanilla Ice Cream
		Dinner		
Strip Steak Baked Potatoes Asparagus Spears Dinner Roll Apple Cobbler	Chicken Kiev White Rice Mixed Vegetables Dinner Roll Fudge Cake	Baked Ham with Pineapple Glaze Au gratin Potatoes Buttered Green Peas Dinner Roll Cherry Cobbler	Short Ribs of Beef Buttered Peas with Mushrooms Whole Kernel Corn Dinner Roll Pecan Pie	Lobster Newburg White Rice French Style Green Beans Dinner Roll Almond Torte

[a]Instant coffee, tea, butter, and sterilized canned whole milk were available at each meal.

TABLE VII. FOOD CONSUMPTION DURING NOMINAL APOLLO LUNAR LANDING MISSIONS

Food Type	Quantity Provided on Apollo —			Quantity Consumed on Apollo —			Percent Consumed on Apollo —		
	11	12	14	11	12	14	11	12	14
Breakfast Items	51	44	38	27	27	29	52.9	61.4	76.3
Salads and Soups[a]	18	15	16	16	8	5	88.9	53.3	31.3
Meats[a]	30	22	20	4	7	4	13.3	31.8	20.0
Desserts[a]	24	20	15	0	10	5	0	50.0	33.3
Fruits[b]	18	18	6	10	15	6	55.5	83.3	100.0
Beverages[a]	75	75	70	45	47	65	60.0	62.7	92.9
Bite Size	48	30	39	26	14	38	54.2	46.7	97.4
Thermostabilized	30	30	30	14	23	25	46.7	76.7	83.3

[a]Rehydratable.
[b]Intermediate moisture.

and no accidental dispersion of food occurred. Eating food in null gravity using ordinary tableware spoons proved to be a complete success. The spoons are the size referred to in the industry as serving spoons, which are the intermediate size between a teaspoon and a tablespoon.

The CDR and the LMP consumed the foods as outlined in the programmed menus, and the body weight of each was maintained throughout the mission. The CMP deviated slightly from the programed menus and reported that the quanity of food supplied for each meal was greater than his need. A smaller variety of high-preference items would have been more acceptable. The body weight of the CMP at recovery was slightly less than that recorded preflight. The crew members reported that undissolved gas existed in the water supply, but the gas caused no significant problem with proper rehydration of food.

The food consumption by type during the Apollo lunar-landing missions is given in Table VII. During these missions, consistent consumption rate of 50% or greater has been recorded only for breakfast items, beverages, and IM fruits. Foods are selected for flight only after careful consideration of the food preferences of each individual crew member. Ground-based crew member food-preference ratings have proved to be a poor basis for predicting inflight food consumption. The implication of these findings is that the conservative approach in the design of a space food system requires an oversupply of foods to allow for inflight shifts in food-acceptance patterns.

The fact that solid and semisolid foods can be consumed in null-gravity from open containers by using conventional tableware has been established during the Apollo Program. Expansion of the list of suitable foods on future Apollo flights will provide an extensive selection of foods in a variety of forms that not only will meet the unique requirements of Skylab, space shuttle, and space station missions but also will be highly acceptable to individuals with a variety of food preferences.

Food-system improvements during the Apollo Program have laid the groundwork for the food system for the Skylab Program. The Skylab vehicle will be manned in earth orbit by three crews of three men each. The first crew is scheduled to inhabit the spacecraft for 28 days; the next two crews, for 56 days each. All food will be on board at the time of the initial launch of the Skylab vehicle. The food advances scheduled for Skylab are the use of frozen foods, an improved liquid-food dispenser, facilities to eat all nonliquid foods from open containers, a greater variety in the menu, and equipment for heating food.

Since the flight of Freedom 7 (Mercury 6), the evolution of space food systems has been marked by the application of technological principles to design and develop unique food formulas and packages so highly acceptable, safe, nutritious, and convenient food would be available for the astronauts. These systems have been constrained particularly by the limited weight and volume allowed in spacecraft. The success of this food program has resulted from the stepwise improvement of the food system with each succeeding space flight. By means of this type of evolutionary improvement, the requirements for food systems for the more sophisticated space flights of the future will be met.[8]

The new generation of manned orbital space flights will begin when the space shuttle program is activated in the mid-1970's. During preliminary food-system-design studies for the space shuttle, it has been determined that optimum overall food-system performance can be obtained by maximizing the use of rehydratable foods. Rehydratable foods allow maximum vehicle payload because food weight is reduced by approximately 80 percent when water is removed. Adequate water for rehydration is available from fuel cells. Excellent rehydratable foods are in the current space-flight food inventory. These foods have been developed and verified for flight during the Mercury, Gemini, and Apollo missions. The advantages of diets composed of rehydratable foods also have been verified by comprehensive studies of the physiological performance of crew members in earth-based situations.[3,4,11] The space shuttle program also will require a unique, fast-response, ground-based-resupply food-service program of airline design.[2] The results of trade-off studies have established that this type of logistical system can be adapted best to space flight by utilizing rehydratable foods. Thus, the advances achieved in the Apollo food program will continue to have a strong influence on the development of food programs for future space missions.

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APPENDIX B

FOOD HANDLING PROCEDURES

FOOD HANDLING PROCEDURES

A. Acquisition of Food

1. Frozen prepared foods selected by NASA for use in feeding CRA personnel shall be ordered directly from the processor. Frozen food obtained from these processors shall comply with the Statement of Work and shall be procured under the terms of a BPA Purchase Request (Buyer: Mrs. Pat Curry, BG 85, Ext. 7766).

   Information regarding the food sources is outlined below:

   a) Stouffer Foods Corporation
   1375 Euclid Avenue
   Cleveland, Ohio 44115

   Telephone: (216) 861-3450

   Sales Representatives:
   Messrs.
   Howard R. Elder
   Carl Schlabach
   Jerry Childs

   b) O'Brien, Spotorno, Mitchell
   2455 Mason Street
   San Francisco, California 94133

   Telephone: (415) 771-2300

   Sales Representative:
   Mr. Dan Greer

2. Staple and perishable foods shall be purchased from local retail grocery outlets under the terms of a BPA Purchase Request (Buyer: Mrs. Pat Curry, BG 85, Ext. 7766). These foods will be purchased three times per week in quantities sufficient for feeding quarantined personnel.

Local food sources are designated below:

a) Weingarten's Store No. 70
18091 Upper Bay Road
Houston, Texas 77058

Store Manager:
Mr. Gene Adams

b) Piggly Wiggly #436
16701 El Camino Real
Houston, Texas 77058

Store Manager:
Mr. Joe Pieberhoser

3. Food inventory forms shall be used by the CRA Chief Steward to maintain a daily record of food on hand. This information shall be transmitted at least daily to the Chief of Food and Nutrition (Malcolm C. Smith, Jr., D.V.M.) or his designated representative.

B. Storage of Food

1. Adequate supplies of food for the first seven days of the quarantine shall be available when the quarantine is initiated. Frozen foods shall be stored in the freezers in the CRA Kitchen (Room 1-42). Frozen food shall be re-supplied to the CRA at least twice during the nominal quarantine period.

2. Nonperishable staple items shall be stored in the kitchen pantry (Room 1-41) and the kitchen cabinets (Room 1-42).

3. Frozen foods delivered to the LRL shall be held in the freezer in Room 1-40 until they can be passed into the CRA.

4. Perishable items shall be stored in the refrigerators in Room 1-42 (kitchen) and Room 1-41 (pantry).

C. Transfer of Food into CRA

Items of food brought into the CRA during quarantine, for replenishment or for any contingency, shall be transferred into the CRA as follows:

1. The Chief Stewart shall notify Malcolm C. Smith, Jr., D.V.M., or his designated representative of the quantity requirements of food items stored in Room 1-40.
2. Requested perishable food-stuff will be removed from the refrigerator in Room 1-40 and placed in an insulated cooling container.
3. Staple items requested will be placed in storage containers.
4. The filled food containers will be loaded in the autoclave in Room 1-39 after ascertaining that the amber door-signal light is off.
5. The autoclave door will then be closed and CRA Steward notified via intercom.
6. After ascertaining the amber door-signal light is off, the CRA personnel will open the autoclave door from their side and transfer the filled food containers out of the autoclave chamber.
7. Each container of food transferred into the CRA shall be accompanied by a signed certificate verifying that all food has been inspected with respect to count, condition and wholesomeness. Malcolm C. Smith, Jr., Clayton S. Huber, and Glenda Lawrence of Food and Nutrition (DC-7) are the only individuals authorized to sign the certificate.

8. Normally, food shall be transferred into the CRA at the following times:

10:00 A.M.
2:00 P.M.
4:00 P.M.

Note: The autoclave must pass through a sterilization cycle before door to the noncontaminated side can be opened again.

D. Preparation of Food

1. Meals shall be prepared and served three times daily by the Chief Steward. The Assistant Stewards will assist when necessary.
2. Meals shall be prepared according to menus furnished by NASA.
3. Frozen prepared foods shall be prepared as prescribed by the supplier, by one of the following methods:
   a. Conventional oven
   b. Range
   c. Microwave oven
   d. Infrared oven
   e. Grill
4. Indicated staples shall be prepared in accordance with recipe directions.

E. Serving of Food

1. Time (Note: These specified times may be modified as required by the CRA Director).
   a. Breakfast shall be served between the hours of 0700 and 0830.
   b. Lunch shall be served between the hours of 1130 and 1300.
   c. Dinner shall be served between 1630 and 1800 hours.

F. Contingency Feeding Plan

1. If the quarantine barrier in the Lunar Sample Laboratory is broken, food must be provided for additional personnel (approximately 100) that will be quarantined. Food which may be stored at room temperature shall be utilized for the initial 24 hour period. This food will be stored in Bldg. 421.

   If the contingency feeding system is required, the LRL representative will call extension 4791 during normal duty hours to request delivery of the emergency food. During off-duty hours, the following personnel from the Transportation Branch will be called at home to arrange the emergency service (in the order listed):

	Office	Home
David B. Homer	483-2315	474-2981
Horace L. Bell	483-5416	877-1255
Raymond L. Brazil	483-4791	422-5936
William M. Patton	483-3258	487-2067

   The MSC Form 174, Request for Move, will be processed by the LRL immediately following the telephone emergency request or on the first normal duty period following.

   Malcolm C. Smith, Jr. (Office 483-5056; home 471-1984) or Clayton S. Huber (Office 483-5056; home 591-2613) shall be contacted to sign the Food Inspection Certificate.

   Instructions for preparation are included within the package. Each individual meal contains the following components:

One freeze dried main dish

One package of cocoa beverage

Two packages of instant coffee

One package of sugar

One package of coffee whitener

One candy bar

Eight freeze dried main dishes shall be provided:

Beef Stew

Chicken Stew

Spaghetti and Meat Sauce

Beef with Rice

Pork and Potatoes

Beef and Hash

Beef Almondine

Chunk Chicken with Rice and Carrots

2. After the first 24 hour period, foods similar to those provided for the nominal CRA quarantine shall be used for the remainder of the contingency feeding. Breakfast shall be prepared from fresh foods purchased locally. Lunch and dinner shall be prepared from frozen precooked food delivered daily to the Lunar Receiving Laboratory. The frozen food shall be purchased from Stouffer Foods Corporation and stored at Glazier Frosted Food Company, 2216 Silver Street, Houston, Texas. Delivery shall be made by Glazier Frosted Food Company if a contingency feeding system is required. (Contact Mr. Tom Jamail. Telephone No. 809-6411).

Malcolm C. Smith, Jr. (483-5056) has the responsibility for the procurement and delivery of these food items. The contingency frozen food shall be supplemented with fresh foods purchased locally.

3. Disposable eating utensils shall be used for all contingency feeding systems.

APPENDIX C

NUTRITION SYSTEMS FOR PRESSURE SUITS

Nutrition Systems for Pressure Suits

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Technology Incorporated, and National Aeronautics and Space Administration, Houston, Texas 77058

HUBER, C. S., N. D. HEIDELBAUGH, R. M. RAPP, and M. C. SMITH, JR. *Nutrition systems for pressure suits.* Aerospace Med. 44(8):905-909, 1973.

Nutrition systems were successfully developed in the Apollo Program for astronauts wearing pressure suits during emergency decompression situations and during lunar surface explorations. These nutrition systems consisted of unique dispensers, water, flavored beverages, nutrient-fortified beverages, and intermediate moisture food bars. The emergency decompression system dispensed the nutrition from outside the pressure suit by interfacing with a suit helmet penetration port. The lunar exploration system utilized dispensers stowed within the interior layers of the pressure suit. These systems could be adapted for provision of nutrients in other situations requiring the use of pressure suits.

THE PHYSIOLOGICAL, psychological, bacteriological, and biochemical effects on individuals wearing pressure suits have been extensively studied.[1,2,3,4] Nutrition in these studies was usually provided by transferring water and food into the suit from outside. This necessitated penetration of the suit helmet or faceplate. Such penetrations of pressure suits during normal operations in the hard vacuum of space entail unacceptable hazards.

The Apollo Program provided for the contingency in which the Command Service Module (CSM) would be depressurized during flight and the astronauts would be required to wear pressure suits until reentry. In this contingency, cabin depressurization would have persisted for up to 115 hr and an intake of fluids would be essential to sustain life.

Apollo lunar explorations required astronauts to eat while wearing their pressure suits. As the duration of journeys on the lunar surface increased, the necessity of providing proper fluid and nutrients became increasingly critical. Apollo astronauts estimated that work periods on the lunar surface of up to 10 hr were within their physical capability; however, periods up to 4 hr required fluids and solid nutrients to insure proper physiological performance.

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Nutrition support systems were developed for pressure suit feeding to meet the requirements of the Apollo Program. These systems are described and discussed in this paper.

APOLLO PRESSURE SUIT

The Apollo pressure suit is shown in Fig. 1. This suit fits directly over a cooling garment in which cooling water is circulated to transfer metabolic heat from the astronaut's body. The first inner layer of the Apollo pressure suit is a comfort layer of a lightweight, heat-resistant polyamide. Progressing outward, the subsequent layers are as follows: a gas-tight bladder layer of neoprene-coated nylon which maintains the pressure of the suit, a nylon restraint layer which prevents the bladder from ballooning, a lightweight super-insulation con-

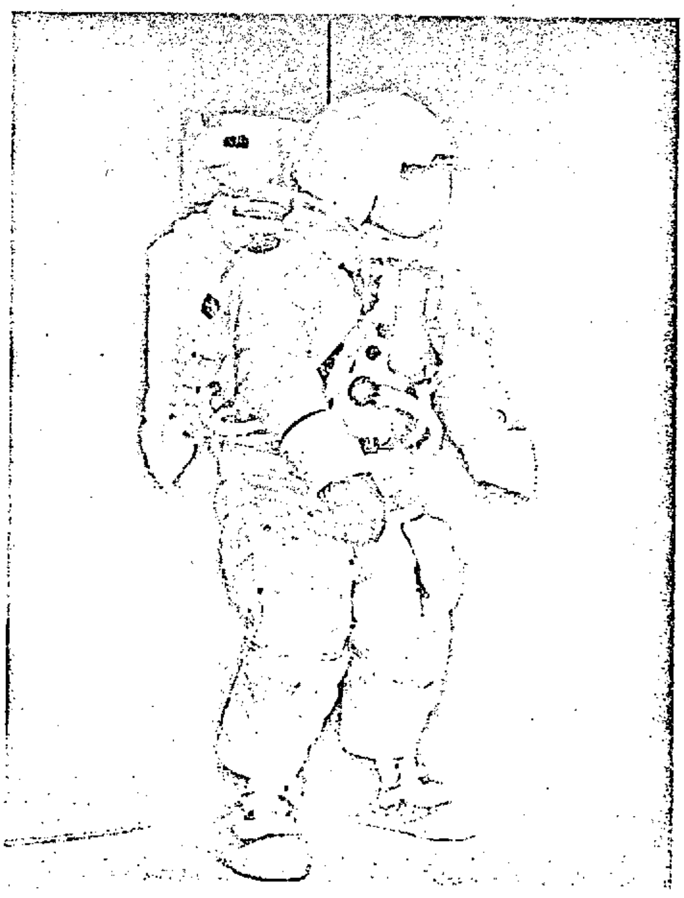

Fig. 1. Apollo pressure suit.

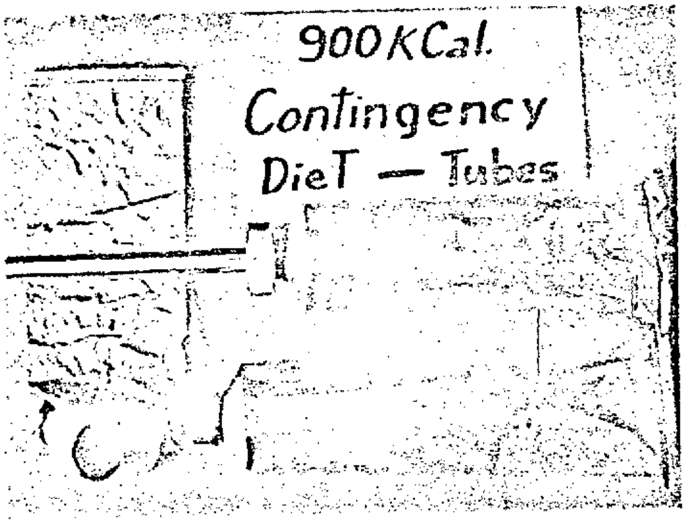

Fig. 2. Apollo nutrient-defined semisolid food.

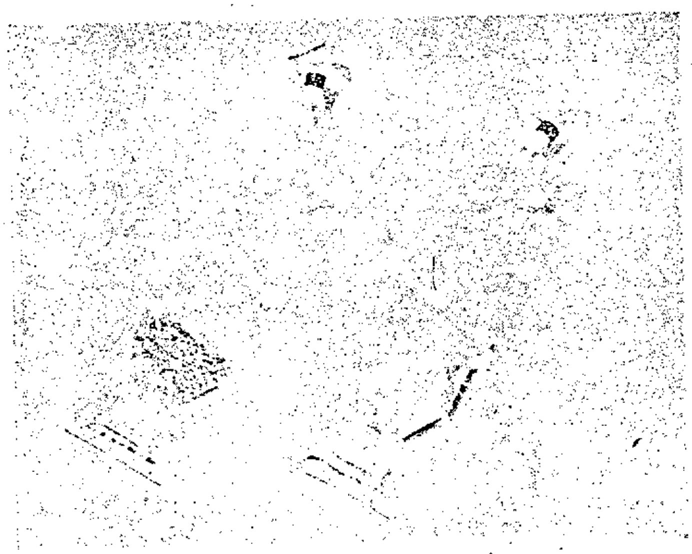

Fig. 3. Apollo rehydratable food packages.

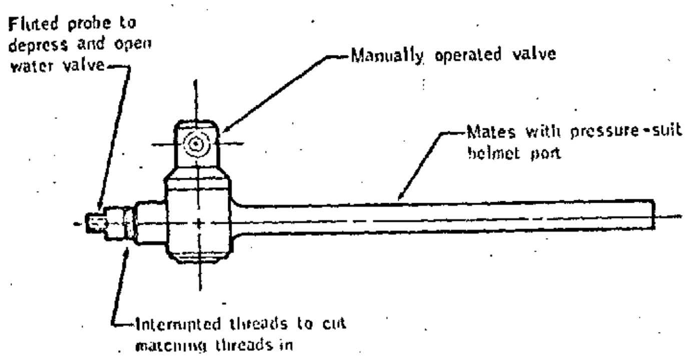

Fig. 4. Pressure suit penetration tube with valve adapter inserted into food package rehydration valve.

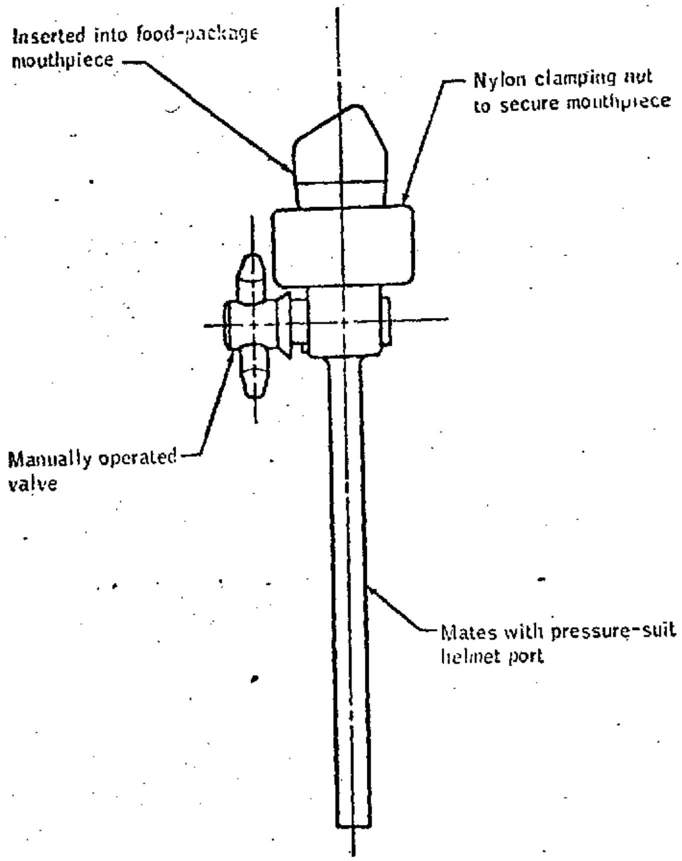

Fig. 5. Pressure suit penetration tube with valve adapter for insertion into food package mouthpiece.

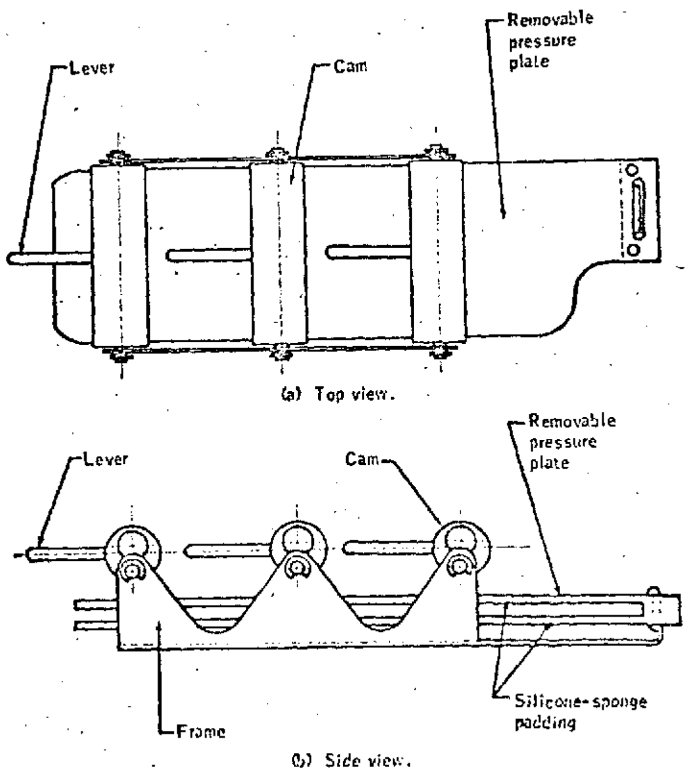

Fig. 6. Food package restraint assembly.

sisting of alternating layers of very thin metalized polyamide film and glass-fiber cloth, several layers of polyester and spacer material, followed by protective outer layers of Teflon-coated glass-fiber cloth and Teflon cloth.

Under normal conditions of use, i.e., on the lunar surface or in the CSM, the internal pressure of the suit is approximately 3.5 PSIA. The bubble-shaped pressure suit helmet is formed from a high-strength polycarbonate plastic. It is attached to the suit by a pressure-sealing neckring. Unlike Mercury and Gemini pressure suit helmets, which were fitted closely and moved with the astronaut's head, the Apollo helmet is fixed; and the astronaut's head is free to move.

The A7L helmet of the Apollo pressure suit is equipped with a penetration port which is located on the left side—near the left ear when the helmet is in place. This location makes drinking and eating extremely awkward but not impossible. In most instances, the astronaut requires the assistance of a fellow crewmember when using the helmet penetration port.

CONTINGENCY NUTRITION SYSTEM

A contingency nutrition system was developed for the event that the spacecraft cabin would be depressurized which would have required the astronauts to wear their pressure suits for up to 115 hr. Several approaches were evaluated in the development of this contingency nutrition system.

One system utilized a nutrient-defined semisolid food contained in flexible metal tubes. Each tube had an insertion tube attached (see Fig. 2). It was found, however, that astronauts wearing the pressurized suit in an evacuated chamber could not exert sufficient external pressure to force the semisolid food from the metal tube, through the insertion tube and into their mouth. This resulted primarily from the positive pressure differential (3.5 PSIA) within the suit combined with the flow properties of the food.

Another design approach utilized the Apollo rehydratable food packages (Fig. 3). Valve adapters or insertion tubes were designed which could be attached to the rehydration valve of the package (Fig. 4) or the mouthpiece of the food package (Fig. 5). A device (Fig. 6) to restrain the food package and assist in expelling liquid food through the insertion tube was constructed. This restrainer assembly concept incorporated cams and levers to force the food from the package through the adapter into the astronaut's mouth.

When the food package adapters were tested, the food packages ruptured. The point of failure was in the heat sealed side seams. Although the food package heat seals are tested for integrity at a differential pressure of 9 PSIA during fabrication, a sudden change in the internal pressure usually resulted in rupture. Prolonged internal pressure with external manipulation to express liquids through the port resulted in a 25% failure rate at the side seams. The metallic, food package restrainer-assembly (Fig. 6) proved to be unacceptable since it was awkward to use, very heavy and bulky, and did not provide adequate support to prevent rupture of the side seams. In contrast, the mouthpiece adapter had some advantages, e.g., more viscous foods could be consumed because of the larger orifice at the point of attachment. However, attachment of the mouthpiece adapter to the polyethylene tube on the food package caused the polyethylene to split and it proved difficult to manipulate with the gloved hands.

Fig. 7 illustrates the evolution of the valve-adapter insertion tube which was designed to interface with the rehydration valve of the food package. The shut-off valve was incorporated into the valve-adapter to prevent loss of critical, internal suit pressure in the event of a rupture of the beverage package, to prevent loss of liquid from the package after rehydration, and to prevent the sudden surge of pressure into the package when the tube was inserted through the helmet penetration port. With the shut-off valve, the pressure inside the package could be gradually equalized with the in-suit pressure without rupture of the food package when used with a nylon restrainer pouch. The insertion tube was lengthened for easier in-suit access. The one disadvantage of the valve adapter was that the orifice at the point of attachment was small and only liquids could be used.

Another approach was a restrainer to prevent rupture of the food package. The nylon restrainer pouch shown in Fig. 8 was included in the Apollo 8 system. Although this design prevented rupture of the food package, it was difficult and a time-consuming procedure for the crew to insert the food package into the pouch while wearing pressurized gloves.

Fig. 9 shows the final design of the food restrainer pouch. This design proved to be successful. A double-zipper pouch enabled the astronaut to insert the package into a relatively large opening and then restrain it further by closing the second zipper. The only problem encountered in the evaluation of the nylon restrainer pouch was a failure in the package between the main section of the package and the germicidal tablet section. This germicidal tablet is used to stabilize the residue left in the bag after eating. This problem was eliminated by

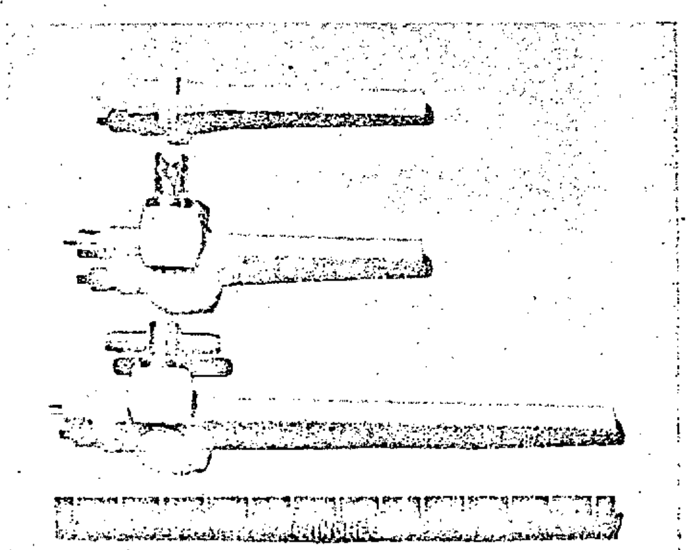

Fig. 7. Valve adapter pressure suit penetration tube evolution, with earliest concept at top of photograph, then intermediate concept, and final design at the bottom.

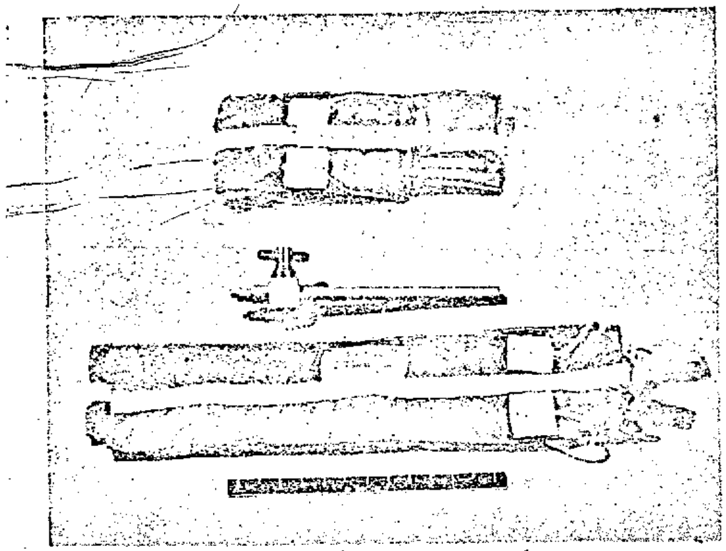

Fig. 8. Food package restrainer pouch.

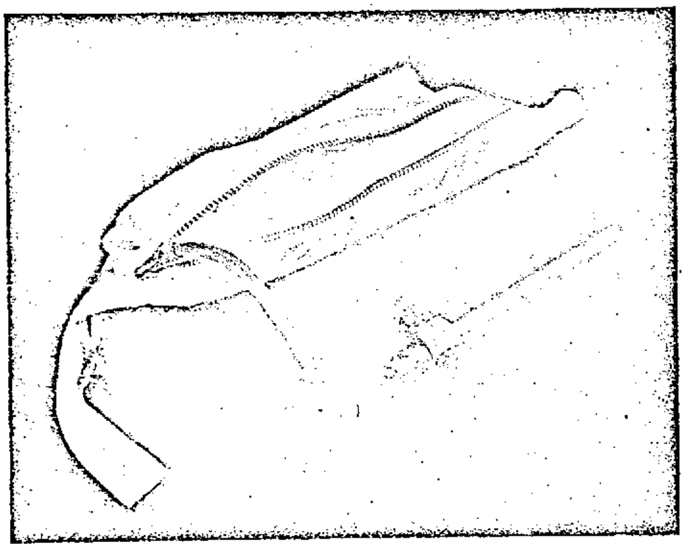

Fig. 9. Final design of food package restrainer pouch with rehydratable beverage package installed prior to closing zippers.

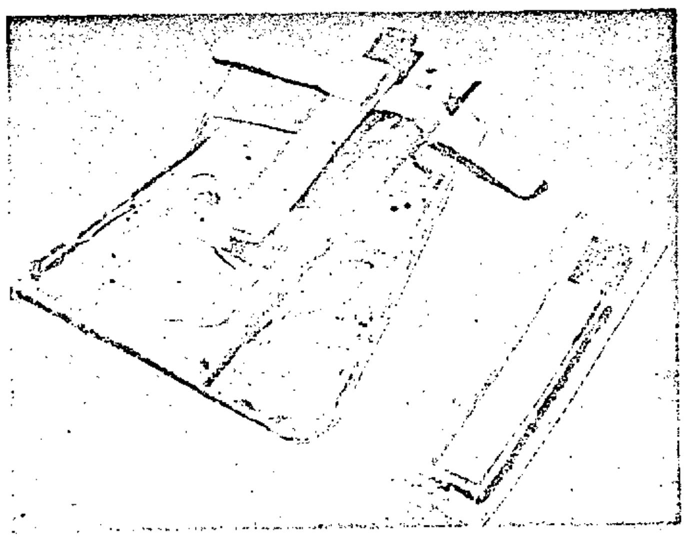

Fig. 10. In-suit food and fluid dispensers (Apollo 15, 16, and 17).

removing the germicidal tablet and its associated compartment from the package. The contingency feeding system, as provided for Apollo 10 through 17, consisted of one valve-adapter insertion tube and three nylon food-restrainer pouches. Each restrainer pouch contained a package of beverage powder.

Thus, for initial use, the astronaut would rehydrate the beverage powder and attach the insertion tube. After drinking this beverage, the empty package would be replaced with additional packages of beverage powder. As it developed, there was no requirement for use of this system during any Apollo flight. However, ground-based tests verified its function.

THE LUNAR EXPLORATION NUTRITION SYSTEM

The lunar exploration nutrition system was designed to provide fluids and nutrients to support crewmen during lunar surface operations. The concept utilized dispensers placed within the pressure suit thus eliminating the requirement for utilization of a penetration port in the helmet. A beverage dispenser and a solid food dispenser were designed. A fluid dispenser was first utilized on the Apollo 14 mission. This dispenser had a capacity of 8 oz. During the Apollo 14 lunar exploration, each astronaut consumed water from his dispenser. This marked the first time that fluids were consumed by man outside of a space vehicle and away from earth.

The fluid dispenser used on Apollo 15, 16, and 17 (Fig. 10) was similar to the configuration of that on Apollo 14 except that it had a capacity of 32 fluid ounces. All of the dispensers were made of 3 mil polyurethane. The dispensers were fitted with a latex tube and a check valve used to retain the liquids within the dispenser. Liquids were removed from the dispenser by opening the check valve and sucking. The dispenser was placed between the restraint layer and the polyamide layers of the Apollo space suit. The Commander and Lunar Module Pilot were each provided with a beverage dispenser. During the lunar surface activity of Apollo 15 and 17, the container was filled with 32 oz of water. For Apollo 16, the dispenser was used for lunar surface consumption of 32 oz of orange drink fortified with 10 mEq of potassium (as potassium gluconate).

Several food bars were developed for the solid food dispenser. The bars were composed primarily of natural fruits, gelatin, sugar, and water. Seven varieties of bars were developed (apricot, cherry, plum, raspberry, lemon, strawberry, and spiced apple). The bars were designed to be stable at room temperature by adjusting their equilibrium relative humidity (water activity) to 65% (i.e., they would neither gain nor lose moisture in an environment of 65% relative humidity). This condition inhibited microbiological growth. Apricot food bars were used on the Apollo 15 mission. This marked the first instance of man consuming solid food while wearing a pressure suit outside of a space vehicle. On Apollo 16, lemon, apple, and cherry bars were consumed, and on Apollo 17, apricot and cherry bars. Each 2.5 x 22.9 x 0.6 cm bar weighed between 53 and 62 g. One bar provided approximately 188 Kilocalories. A typical food bar is shown in Fig. 10. Each bar was covered with an edible starch film to prevent the product's stickiness from interfering with release of the bar from the food dispenser. The edible film was consumed along with the bar.

After wrapping the food bar in the edible starch film, it was inserted into an elastic nylon food dispenser. Velcro patches were attached to the nylon for anchoring the dispenser and bar to the fluid dispenser and the neckring of the pressure suit (Fig. 11). The food was consumed by grasping the bar with the teeth and pulling it from the dispenser. When an adequate amount was dispensed, a bite was taken and the product consumed. The method for dispensing proved satisfactory and no difficulties were experienced in handling or consuming the solid food.

All food used in the Apollo food system complied with strict microbiological limits. Typical bars had total aerobic counts between 200 and 4000 per g and counts of less than 1 per g for coliform, fecal coliform, fecal streptococci, yeast, and mold. These bars also had less than one coagulase positive staphylococci per 5 g and negative for Salmonella in 10 g. Microbiological testing was performed in accordance with Apollo food microbiological procedures.[5] Beverages dispensed from in-suit devices had similar microbiological profiles.

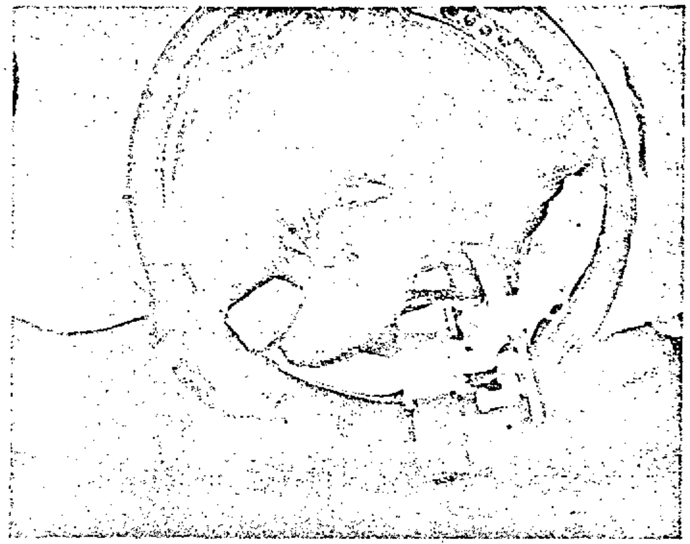

Fig. 11. Food and fluid dispensers attached to helmet neckring of pressure suit.

DISCUSSION

Pressure suits will be one of man's most useful tools in his efforts to continuously expand the horizons of his explorations. Aside from the more obvious needs for pressure suits in space explorations (jointly sponsored international flights, satellite repair, space stations, lunar bases, planetary bases), man will be increasing his need for controlled pressure environments in the seas (sealabs, resource explorations), in high performance aerospace vehicles, and in other exotic environments involving earth resources management. Such operations will require increasing durations of pressure suit protection with concomitant need for proper nutrition.

Pressure suit nutrition systems have been developed for the Apollo program. These systems were successfully used on the epic flights of Apollo 15, 16, and 17. The development of these systems represent a significant contribution to man's conquest of hositle environments.

ACKNOWLEDGMENTS

The authors wish to thank the following individuals for their valuable suggestions and help which led to the final design and fabrication of these systems: Mr. Gerald Swaney, Technology Inc.; S/Sgt. Frank Hernandez, Jr., USAF; Mr. Floyd Harrison and Mr. Matthew Radnofsky, NASA-JSC; and Captain Alan Bean, USN, astronaut.

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APPENDIX D

MODIFICATION OF THE PHYSICAL PROPERTIES OF FREEZE-DRIED RICE

United States Patent Office

3,692,533

Patented Sept. 19, 1972

1

3,692,533

MODIFICATION OF THE PHYSICAL PROPERTIES OF FREEZE-DRIED RICE

Thomas O. Paine, Administrator of the National Aeronautics and Space Administration, with respect to an invention of Clayton S. Huber, Houston, Tex.

No Drawing. Filed Aug. 28, 1970, Ser. No. 68,023

Int. Cl. A23l 1/10

U.S. Cl. 99—80 PS 8 Claims

ABSTRACT OF THE DISCLOSURE

A process for preparing dehydrated rice wherein the rice is cooked in water to a gelatinized state. The grain includes about seventy-five percent moisture content. Thereafter, the granular rice is subjected to freezing and then thawing for two or more cycles. Then, it is frozen and freeze dried to remove moisture. The dehydrated granular rice is quickly rehydrated by placing it in hot water.

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

SUMMARY OF PROBLEM AND SOLUTION

Rice is extremely significant as a staple food throughout the world. It is normally time consuming to prepare and serve as a fluffy granular product which is sufficiently tender to be eaten. Numerous processes have been advanced in the past to prepare "instant" rice. However, even instant rice requires perhaps five minutes of simmering or cooking time. Parboiled rice will sometimes require as much as one-half hour of cooking time to serve a product which is both tender and edible. Even greater periods of time are required to prepare brown rice and regular white milled rice. Quite clearly, the difficulties in preparing rice center principally on the time required for its preparation. Reducing the preparation time of rice would, in essence, create a new convenience food.

The method of the present invention is directed to a manner of preparing rice which provides a product which is quickly prepared, relatively light weight, easily stored, and conveniently handled. The final product is a dehydrated rice granule which is substantially reduced in weight and which can be quickly prepared and served, requiring only perhaps a minute of exposure to hot water. For instance, the final product has been reconstituted and served by placing it in water at 200° F. for just under one minute. The method of the present invention therefore is summarized as including a first step of cooking rice in water over a low heat until the rice is tender. When the rice becomes tender and edible, it is then subjected to the following steps.

It is first frozen, and thereafter thawed. Preferably this is repeated for two complete cycles. Thereafter, it is frozen a third time, and then the ice crystals in the rice granules are sublimated by freeze dehydration. Application of heat by means of heating platens facilitates the sublimation process.

Upon completion of the foregoing process, a dry, light weight, granular product which can be quickly rehydrated has been prepared. Rehydration can be accomplished in a matter of a few seconds. Typically, only a minute or so is required to rehydrate the rice.

While the foregoing summarizes the invention, the following specification is set forth in greater detail, the description being accompanied by no drawings.

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The rice to be treated by the method of the present invention is not limited to any particular variety of rice, but is intended for those varieties which are readily available in the United States and quite common to the Oriental countries also. The rice is cooked in water for a sufficient interval of time to become tender and edible. Preferably, it is cooked over a low heat to avoid damage to the kernel and to avoid preparation of a pasty, cohesive mass as opposed to individual grains or kernels. When the cooked rice becomes tender and edible, the next several steps are applied to the rice. The tender and edible rice is frozen and subsequently exposed to two cycles of consecutive thawing and freezing. The freezing is preferably done at quite low temperatures, perhaps in the range of −10° C.– −20° C. While temperatures closer to the freezing level may be used, in the interest of time and expediency a colder temperature is preferably used to quickly freeze the water in the granules.

Thawing is preferably accomplished at room temperature, perhaps in the vicinity of 20° C.–22° C. It is speculated that the porosity of the granule is altered to some extent by the repeated freezing and thawing. Apparently, the porosity is improved in a manner such that the rice particle absorbs the water more readily. This also means that the water is more readily removed, as will be described hereinafter. In any case, the change of porosity enables and permits the rice to quickly reabsorb water when the product of the present invention is later reconstituted.

The cooked rice is subjected to preferably two cycles of thawing and freezing after the initial freezing treatment. While one cycle has been attempted experimentally, the results at least permit substantial rehydration at a much slower rate. Three cycles or more have likewise been attempted, and the results are sometimes improved, but not necessarily so, and may vary dependent on many factors. Consequently, the two cycles constitute the preferred method of the present invention.

After the two complete cycles of thawing and freezing are finished, the ice crystals (water) in the kernels of rice are removed by the freeze drying process. The granular rice is placed on trays within a freeze drying chamber. Heated platens are located above and below the trays which contain the granular rice. The chamber pressure is reduced to less than two hundred fifty microns. At this pressure, heat is applied to the heating platens above and below the trays. The platen temperature is maintained approximately 50° C. during the drying cycle. The ice crystals within the grains of rice are converted into water vapor without passing through the liquid state and, of course, the vapor condenses on refrigerated coils in the chamber maintained at a very low temperature, such as in the range of −60° C. The moisture content (by weight) of the rice granules is less than 3.0 percent at the conclusion of the drying cycle. The product which remains is the granular rice, absent the water, and is a product which is easy to package, requires no refrigeration, and if properly packaged, can be stored indefinitely without undesirable effects.

The dehydrated granules prepared in accordance with the method of the present invention can be readily reconstituted by placing them in water having temperatures in the range of about 50° C. to 100° C. At about 100° C., water will reconstitute the rice prepared in accordance with the present invention within one minute. At lesser temperatures, the process requires somewhat more time, but is still accomplished within one or two minutes. The rehydrability of freeze dried rice has been modified by the consective freezing and thawing cycles.

The ability of the product to be prepared rapidly points out the possibility that the method of the present invention can be used in preparing rice for field uses, as might be found for military personnel, or for campers, and also finds use in preparing a light-weight food which can be prepared quickly by astronauts. The finished product is, as has been emphasized, fully equal to the finished product of conventional rice preparation methods.

The foregoing is directed to the preferred method of the present invention. Deviations and alterations of the method set forth can be supplied by those skilled in the art. The scope of the present invention is determined by the claims which are appended hereto.

What is claimed is:

1. A method of preparing granular rice, comprising the steps of:

(a) cooking granular rice in water over a low heat until the granular rice is tender and edible;

(b) freezing and thawing the granular rice for two cycles;

(c) thereafter freezing the granular rice again; and,

(d) freeze drying the granular rice to reduce the moisture content to not more than four percent.

2. The invention of claim 1 wherein the freezing is accomplished at a temperature of about −10° C. or below.

3. The invention of claim 2 wherein the thawing is

accomplished at ambient room temperatures in the range of approximately 22° C.

4. The method of claim 1 wherein the freeze drying of the rice is accomplished in a closed chamber where the pressure is reduced to less than two hundred fifty microns.

5. The method of claim 1 wherein the drying of the rice is accompanied with heat in the range of approximately fifty degrees centigrade, which is not initiated until after the pressure within the chamber is reduced.

6. The invention of claim 1 wherein the rice is reconstituted by placing it in water having a temperature ranging from approximately fifty to one hundred degrees centigrade for an interval approximating one minute.

7. The method of claim 1 further including the step of rehydrating the rice by placing it in water at about ninety degrees centigrade for about one-half minute.

8. The granular rice as a product prepared in accordance with the method of claim 1.

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RAYMOND N. JONES, Primary Examiner

APPENDIX E

STABILIZATION OF AEROSPACE FOOD WASTE

Reprinted from Journal of Milk and Food Technology, October 1971, Vol. 34, No. 10 (P. 478-481)

THE RELATIVE EFFECTIVENESS OF 8-HYDROXYQUINOLINE SULFATE AND ALKYL DIMETHYL BENZYL AMMONIUM CHLORIDE IN THE THE STABILIZATION OF AEROSPACE FOOD WASTE[1]

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(Received for publication April 13, 1971)

Abstract

The relative effectiveness of 8-hydroxyquinoline sulfate and alkyl dimethyl benzyl ammonium chloride (a quaternary ammonium compound) were compared for their ability to prevent growth of microorganisms in aerospace food waste. Alkyl dimethyl benzyl ammonium chloride and 8-hydroxyquinoline sulfate were added to samples of banana pudding, chicken salad, cocoa, orange drink, and non-fat milk at concentrations ranging from 0.1 to 4%. The rehydrated foods containing the microstatic agents were incubated at 23 C for 60 days.

Microbiological analyses were performed on aliquots which were withdrawn at various intervals. Aliquots were analyzed for total aerobic count, coliforms, yeasts, and molds. No growth was observed in samples containing 8-hydroxyquinoline sulfate in concentrations >1% and stored at 23 C. Coliforms, yeasts, and molds were not detected in the initial food or during the storage period. Research toward a food waste stabilization system which would prevent growth by decreasing the water activity is recommended.

The formidable problem of food waste stabilization onboard spacecraft has been magnified by the longer flights of Gemini and Apollo. Extended manned spaceflight will pose an even greater challenge for stabilization of residual or waste food. The Skylab Program, which is tentatively scheduled for 1973, will more than double the mission length of manned spaceflight sponsored by the United States. One 28-day and two 56-day missions, with a complement of three astronauts, are projected for the Skylab Program. Food waste on Skylab will be normally disposed of by passage into an outside tank which is at temperature and pressure of the space environment. If the passage lock into this tank should fail an alternate food waste stabilization system, probably based on chemical additives must be available. No completely satisfactory chemical has yet been developed for such an application.

The Apollo Food System utilizes dehydrated, thermostabilized, and intermediate moisture foods packaged in flexible laminated plastic or rigid aluminum containers. Flight foods are consumed directly from their package. Food residue subsequently stowed aboard the spacecraft requires microstatic treatment. This residue is currently treated with 8-hydroxyquinoline sulfate (8-HQS) to prevent microbial growth and subsequent odor and gas production. Treatment is accomplished by insertion of 1 g of 8-HQS in pill form into the package immediately after the food is consumed.

Food waste from the Mobile Quarantine Facility (MQF) also must be treated with a microstatic agent. The MQF serves as a portable isolation ward for the astronauts while enroute from the spacecraft recovery area to the Lunar Receiving Laboratory at the Manned Spacecraft Center, Houston, Texas. The food system aboard the MQF consists of frozen precooked meals supplemented with canned and dried staples. Food waste from the MQF is treated with 8-HQS, sealed in double polyethylene bags, conveyed through the transfer lock, and stored for the duration of the quarantine period. Moisture contained in the food residue from both the spacecraft and the MQF is utilized to dissolve the 8-HQS.

Any remaining untreated food residue may be expected to support microbiological growth with subsequent gas production and putrefaction. If the food packages did not receive adequate microstatic treatment, odors, gases, and spores resulting from the growth of microorganisms could become a serious problem in the confined environment of the spacecraft. If there were gas production in the sealed waste containers from the MQF this could rupture the containers and cause a break in the quarantine. This investigation was prompted by the hazards of inadequate microstatic treatment of waste foods and the lack of sufficient evidence to support microstatic activities of 8-HQS in the presence of food.

[1]This work was performed under contract with the National Aeronautics and Space Administration (Contract No. NAS 9-8927).

Since they are odorless and effective in small concentrations, the quaternary ammonium compounds appeared to be more desirable for Apollo food waste stabilization than 8-HQS. Therefore this study was designed to compare the microstatic activity of 8-HQS and alkyl dimethyl benzyl ammonium chloride (ADBAC) in the presence of food.

Space food systems have been previously described by Heidelbaugh *(8)*. Methods to manufacture foods for these systems were reported by Flentge and Bustead *(6)*. The possible preservation procedures for controlling waste putrefaction during space flight were reviewed by Roth et al. *(9)*. These procedures included jettisoning, heating, refrigerating, desiccating, and treating with chemical agents. Chemical treatment of the food residue appeared to be the most feasible method.

In order to be compatible with the aerospace feeding system and the spacecraft environment, the ideal food waste stabilizer should possess the following characteristics: *(a)* odorless, *(b)* water soluble, *(c)* solid material, *(d)* non-gas forming, *(e)* non-toxic to crewmembers, and *(f)* effective in small concentrations.

The antimicrobial activity of 8-HQS is usually attributed to its capacity to form feebly dissociated chelate complexes. According to Elek *(5)*, the metal chelates are lethal to the cell. This theory was supported by Albert et al. *(1)* who have studied 8-quinolinol extensively. Gershon et al. *(7)* also agreed that the metal chelate becomes an active toxicant by combining with and blocking metal binding sites on enzymes. Albert et al. *(2)* reported that 8-HQS exhibited no antibacterial activity at any concentration in the total absence of iron or copper. Block *(4)* found 8-HQS to be fungistatic rather than fungicidal. Elek *(5)* noted that an increase in the concentration of hydroxyquinoline resulted in reduction of antibacterial action. This paradoxical effect was attributed to the fact that the complexes formed with the excess 8-HQS were less toxic.

Quaternary ammonium compounds have been utilized extensively in the food processing field as sanitizing agents and are more active than many other compounds when tested in the presence of organic material.

MATERIAS AND METHODS

Rehydratable flight food items were utilized to compare the microstatic effectiveness of 8-HQS[1] and ADBAC[2]. Banana pudding, chicken salad, and cocoa were manufactured in accordance with the requirements outlined by Flentge and Bustead *(6)*. These foods complied with the microbiological specifications for space food *(6)*. Orange drink and non-fat dry milk were packaged in the laboratory in packages fabricated from a laminate of 1.00 mil polyethylene, 0.75 mil mylar, 2.00 mil aclar, and 2.20 mil polyethylene.

The quaternary ammonium compound, 50% active ADBAC, was especially prepared for this study. This quaternary ammonium compound possessed the following properties: *(a)* compatible with nonionic surface active agents, *(b)* freely soluble in water, and *(c)* odorless in the powdered form as well as in solution. The microstatic agents, 8-HQS and ADBAC were added to the dry food through the feeding port at the following concentrations: 0.1, 0.5, 1, 2, 3, and 4%. The concentration was based on the total weight of rehydrated food. Sterile distilled water was added through the feeding port to rehydrate the food and microstatic agent mixture. Food packages were prepared for each concentration of microstatic agent and incubated at 23 C. One package of each food which did not contain a microstatic agent was stored under the same conditions to serve as a control. Microbiological analysis of each package was conducted at the following intervals: 0, 5, 15, 30, and 60 days. Eleven-gram sample aliquots were withdrawn through the feeding port and transferred to 99 ml of buffered distilled water. Total aerobic count, total coliform, and total yeast and mold counts were performed in accordance with *Standard Methods for the Examination of Dairy Products (3)*. Analysis for total coliforms was performed with Violet Red Bile Agar (Difco). Samples for total coliform, and yeast and mold were plated at dilutions of 1:1 and 10^{-1}. Total aerobic counts were plated at four dilutions. Initial samples were plated at 10^{-1} through 10^{-4}. Subsequent samples were plated at dilutions based upon the previous count. No attempt was made to inhibit the antimicrobial activity of the agents during the plating procedure because there was no confirmed method of suppressing 8-HQS activity in the presence of food.

RESULTS AND DISCUSSION

The initial total aerobic counts were all <10,000 per gram and were therefore, within the limits established for aerospace food *(6)*. No coliforms were detected in the control samples or the samples containing microstatic agents during the entire storage period. The yeast and mold counts were negative for the entire storage period. The total aerobic counts obtained at the various concentrations of microstatic agents and storage times at 23 C are shown for each food in Tables 1 through 5. Both of the microstatic agents were reasonably effective in controlling growth of microorganisms when present in concentrations greater than 1%. Growth in the chicken salad (Table 1) was more persistent and required more microstatic agent for control. In general, higher counts were obtained from the chicken salad containing 8-HQS (Table 1). However, both compounds required a concentration of 2% to prevent bacterial growth. There were no detectable differences between the two agents in the presence of non-fat milk. A concentration of 0.5% of either compound (Table 2) maintained bacteriostatic conditions throughout the storage period.

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[1]Baker Chemical Co.

[2]Economics Laboratory, Inc.

TABLE 1. TOTAL AEROBIC COUNT (× 10[4]) OF CHICKEN SALAD STORED AT 23 C

Concentration[1] (%)	Days storage									
	0		5		15		30		60	
	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC
0	0	0	89	89	10,000	10,000	93	93	110	110
0.1	0	0	97	87	1,000	1,000	10,000	11,000	10,000	10,000
0.5	0	0	100	120	11,000	130	12,000	1,100	1,100	1,100
1	0	0	110	15	100	100	18,000	1,200	1,200	190

[1]Concentrations >1% produced counts <10 per gram.

TABLE 2. TOTAL AEROBIC COUNT (× 10[4]) OF NON FAT MILK STORED AT 23 C

Concentration[1] (%)	Days storage									
	0		5		15		30		60	
	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC
0	0.11	0.11	110	110	1,100	1,100	0.01	0.01	0	0
0.1	0	0	100	100	0	0	0	0	0	0

[1]Concentrations >0.1% produced counts <10 per gram.

TABLE 3. TOTAL AEROBIC COUNT (× 10[4]) OF COCOA STORED AT 23 C

Concentration[1] (%)	Days storage									
	0		5		15		30		60	
	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC
0	0	0	94	94	10,000	10,000	110	110	100	100
0.1	0	0	93	91	11,000	1,100	1	1	0	1
0.5	0	0	0	100	0	1,100	0	12	0	89
1	0	0	0	78	0	0	0	0	0	0

[1]Concentrations >1% produced counts <10 per gram.

TABLE 4. TOTAL AEROBIC COUNT (× 10[4]) OF ORANGE DRINK STORED AT 23 C

Concentration[1] (%)	Days storage									
	0		5		15		30		60	
	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC
0	0	0	0	0	0	0	10,000	10,000	0	0
0.1	0	0	0	0	0	0	1.3	1.1	0	11
0.5	0	0	0	0	0	100	0	0	0	0

[1]Concentrations >0.5% produced counts <10 per gram.

TABLE 5. AEROBIC COUNT (× 10[4]) OF BANANA PUDDING STORED AT 23 C

Concentration[1] (%)	Days storage									
	0		5		15		30		60	
	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC	8-HQS	ADBAC
0	0	0	120	120	9,800	9,800	0	0	0	0

[1]A concentration of 0.1% produced counts <10 per gram.

Samples of cocoa treated with ADBAC and stored at 23 C exhibited more growth than those treated with 8-HQS (Table 3). A concentration of 1% 8-HQS maintained microstatic conditions but a concentration of 2% ADBAC was required for the same effect. A 0.5% concentration of 8-HQS and 1% ADBAC prevented growth in orange drink stored at 23 C (Table 4). Both compounds were very effective in controlling growth in banana pudding stored at 23 C (Table 5).

Both of the microstatic agents were reasonably effective in controlling growth of aerobic bacteria when present in concentrations >1%. However, it should be noted that neither compound was tested in the presence of food and coliforms or yeast and mold because these microorganisms were not detected in the control samples. These microorganisms could be expected to be a part of the food waste flora as a result of contamination during consumption. The number of genera of microorganisms encountered in this experiment was relatively small since only a few foods were studied and these possessed extremely low microbial counts at the beginning of the study. These data indicate that use of these agents as the sole source of control for microbial growth in food waste, over long periods of time, is not without considerable risk.

The ideal space food waste stabilization agent should be effective in low concentration and possess a broad spectrum of anti-microbial activity. A stabilization agent should also be effective for periods up to 1 year (Skylab System requirement). A mixture of compatible antimicrobial agents with different spectra of activity would be a complex solution to the problem of aerospace food waste stabilization. A satisfactory mixture would be difficult to achieve and verify since many of the antimicrobial agents are not compatible with each other or the spacecraft environment.

Other methods of food waste stabilization need to be studied. One approach could be the control of water activity. All micro-organisms require available moisture for growth; therefore, food waste stabilization could efficiently be accomplished by removal or binding of available water. This might be accomplished by the addition of sodium chloride. Such an approach could be effective against all types of microbial life. The findings of this report indicate that a study of the practical means to control water activity in food waste, as a method to control unwanted microbial growth, merits serious consideration.

ACKNOWLEDGEMENTS

The aid of Judy A. Brockway and Anthony Wagner, Technology Incorporated, for their technical assistance is gratefully acknowledged.

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APPENDIX F

IDENTIFICATION AND QUANTITATION OF HEXADECANAL AND OCTADECANAL IN BROILER MUSCLE PHOSPHOLIPIDS

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IDENTIFICATION AND QUANTITATION OF HEXADECANAL AND OCTADECANAL IN BROILER MUSCLE PHOSPHOLIPIDS*

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ABSTRACT Two unknown compounds were detected in the fatty acid analysis of the phospholipid fraction of chicken muscle, using gas-liquid chromatography. Comparison of the unknown compounds to standards on polar and non-polar gas-liquid chromatographic columns and infrared spectra revealed that the compounds were hexadecanal and octadecanal. These aldehydes were assumed to have been derived from a plasmalogen.

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Plasmalogens have been reported as constituents of various animal lipids (Rapport and Norton, 1962). Plasmalogens are lipids which release aldehydes under certain conditions. Long-chain aldehydes, corresponding to octadecanoic and hexadecanoic acid are bound as enol ethers. Mild hydrolysis and methylation yield dimethylacetals (DMA). Webster (1960) reported the presence of plasmalogens in heart and skeletal muscle of hens. Peng and Dugan (1965) reported a positive reaction of chicken muscle phospholipids with mercuric chloride, hence indicating the presence of an α, β unsaturated ether. The works of Neudoerffer and Lea (1967) indicated the presence of plasmalogen aldehydes in turkey muscle. However, the identification and quantitation of specific aldehydes in chicken muscle has not been reported in previous studies on lipid composition. The present communication relates the identification and quantitation of hexadecanal and octadecanal in phospholipids extracted from raw broiler muscle and from cooked muscle in the non-frozen, frozen and freeze-dried state.

MATERIALS AND METHODS

Lipids extracted from the chicken muscle were fractionated into neutral and polar fractions via silicic acid column chromatography. Methyl esters of the

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esterified phospholipid fraction were separated on polar (DEGS) and non-polar (Apiezon L) columns in a Varian 2100 gas-liquid chromatograph equipped with a flame ionization detector.

Dimethylacetal compounds were isolated from methylated fatty acids (MFA) by converting the acids to their sodium salts and extracting the DMA with ether.

Infrared spectra of DMA's were obtained with a Perkin Elmer 457 infrared spectrophotometer. Material isolated in the preceding step was scanned as a film deposited on a KBr window.

RESULTS AND DISCUSSIONS

Chromatograms obtained during preliminary GLC studies in our laboratories indicated the presence of two unknown compounds. One unknown was eluted immediately preceding the methyl ester of hexadecanoic acid and the other was eluted immediately preceding octadecanoic acid. The retention time of the unknown compounds did not correspond to the retention time of MFA standards, hence it was suspected that the compounds were plasmalogen aldehyde derivatives (DMA). The retention time of the unknown compounds did correspond with the retention time of C16 and C18 DMA standards on a polar (DEGS) and non-polar (Apiezon L) columns. The esterified phospholipid fraction was saponified with subsequent extraction of remaining DMA's with petroleum ether. As anticipated, GLC analysis of the isolate on a polar and non-polar column indicated the two compounds possessed retention time corresponding to C16 and C18 DMA standards.

Innfrared spectrophotometry of the isolate indicated strong absorption in the 1050–1200 cm.$^{-1}$ region, indicative of an acetal functional group. The spectrum did not indicate strong absorption in the 1600–2000 cm.$^{-1}$ region which is characteristic for a carbonyl group.

TABLE 1.—*Percent C16 and C18 DMA in phospholipid fraction of broiler muscle*

Conditions	Thigh Percent		Breast Percent	
	C16	C18	C16	C18
Raw	6.00	2.38	8.54	2.68
Cooked	5.75	1.52	8.41	1.52
Frozen				
−10°C.	5.70	1.70	8.00	1.88
−100°C.	5.87	1.77	8.01	1.74
−195°C.	5.80	1.57	7.44	1.58
Freeze-Dried				
− 10°C.	6.42	1.93	8.89	2.34
−100°C.	6.14	1.73	9.17	2.16
−195°C.	6.33	1.88	8.30	2.13

Hexadecanal and octadecanal were found to be present in both thigh and breast muscle. Both were present in raw muscle and cooked muscle which was subsequently frozen and freeze-dried. The quantity of C16 and C18 DMA found in thigh and breast muscle is illustrated in Table 1.

Since the DMA derivative possesses a similar retention time as MFA derivatives, DMA could easily be mistaken for MFA. For example, Marion and Woodruff (1965) and Marion *et al.* (1967) reported the presence of tetradecadienoic acid in the phospholipid fraction of broiler breast muscle. Similarly, Katz *et al.* (1966) and Miller *et al.* (1967) reported the presence of pentadecanoic acid in the phospholipid fraction of chicken muscle. It is possible that these compounds could have been a C16 DMA since the identification was reported as being tentative in some cases.

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